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Government Spending Effects in Low-income Countries

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Abstract

Despite the voluminous literature on fiscal policy, very few papers focus on low-income countries (LICs). This paper develops a new-Keynesian small open economy model to show, analytically and through simulations, that some of the prevalent features of LICs—different types of financing including aid, the marginal efficiency of public investment, and the degree of home bias—play a key role in determining the effects of fiscal policy and related multipliers in these countries. External financing like aid increases the resource envelope of the economy, mitigating the private sector crowding out effects of government spending and pushing up the output multiplier. The same external financing, however, tends to appreciate the real exchange rate and as a result, traded output can respond quite negatively, reducing the overall output multiplier. Although capital scarcity implies high returns to public capital in LICs, declines in public investment efficiency can substantially dampen the output multiplier. Since LICs often import substantial amounts of goods, public investment may not be as effective in stimulating domestic production in the short run.

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I. INTRODUCTION

Government spending is an important policy tool for countries of all income levels. Relative to other countries, low-income countries (LICs), however, have specific features and needs that may shape the macroeconomic effects of fiscal policy in a particular way. In LICs, for instance, pressing development needs give government capital spending an additional role for promoting economic growth (Sachs (2005)), but declines in the efficiency of this spending—the ratio of the change in public capital to an increase in spending—may substantially diminish the effect of scaling up public investment on growth. Also, in LICs, government spending features a low degree of home bias and can be *externally* financed by aid or borrowing. Both degrees of external financing and home bias play a key role in the transmission mechanism of public spending increases. While higher externally-financed spending may be associated with more real exchange rate appreciation and more pronounced declines of the traded good sector (Rajan and Subramanian (2011)), a low degree of home bias can help counteract these appreciation pressures and negative effects on traded output. Yet there are no systematic studies about the role of these features in determining the effects of fiscal policy, and the associated output multipliers, in LICs.

This paper takes a theoretical approach to analyze the effects of fiscal policy in LICs. Since limited data availability restricts econometric estimations of these effects in those particular countries, we follow Woodford's (2011) approach.[1] We develop a two-sector dynamic new-Keynesian (NK) small open economy model to assess fiscal multipliers in LICs. We first use a simple version of the model—closing the private capital account and ignoring investment—to show analytically the implications of 1) the type of financing in terms of domestic versus external (aid) financing, 2) the degree of home bias, and 3) the real exchange rate on the private sector for consumption and sectoral output. This analysis, we argue, is important to unveil the final effect of government spending on output. Next, we construct a richer quantitative model that incorporates more LIC-specific features to assess more broadly government consumption and investment spending multipliers. The framework includes public investment inefficiencies that capture low governance quality and a myriad of problems in public investment management in LICs, implying that one dollar of investment expenditures yields much less than one dollar of effective public capital.[2] It also contains

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[1] The few papers that estimate government spending effects in LICs are Kraay (2012, 2014). Both papers use datasets of official creditors' lending to developing countries, including LICs. In both papers, Kraay estimates that the short-run output multipliers are around 0.4-0.5. Since loans from official creditors are mostly used to finance public investment rather than consumption, these estimates can be interpreted as the output multipliers for investment projects financed by official creditors. As we discuss below, the type of financing (external versus domestic) matters for the size of the multiplier.

[2] The average scores of LICs lag behind those of developing countries in the public investment management index (Dabla-Norris et al. (2012)) and the Worldwide Governance Indicators (Kaufmann et al. (2013)). For example, the average government effectiveness and corruption control indices in the Governance Indicators for LICs are -1.09 and -0.92 for 2013, compared to the averages of -0.37 and -0.44 for non-LIC developing countries on a scale of -2.5 to 2.5.

other relevant features such as limited international capital mobility and limited asset market participation.[3] Nevertheless, our analysis focuses mainly on the type of financing, the degree of home bias in public spending, and the relative public investment efficiency, as key determinants of fiscal multipliers in developing countries. These features complement the list of other identified key characteristics in the literature, including the degree of development, trade openness, the exchange rate regime, and government indebtedness (Batini et al. (2014) and Ilzetzki et al. (2013)).

We show that the degree of external financing for government spending increases can determine *qualitatively* and *quantitatively* the fiscal policy effects on private activity and on the overall economy. To the best of our knowledge, this is a dimension that has been largely overlooked in the literature. In an environment of restricted capital mobility, external financing increases the resource envelope and thus mitigates the infamous crowding-out effects of government spending. In contrast to the long-lasting negative responses with domestic financing, changes in private consumption and investment with external financing are less negative or can even turn positive. Capital inflows resulted from external commercial borrowing or aid, however, can appreciate the real exchange rate, reducing the competitiveness of traded goods in world markets and, therefore, traded output. The quantitative assessment under our baseline calibration shows that external financing generally produces larger output multipliers than domestic financing, despite the loss of traded output from an appreciated exchange rate.[4] For instance, with relatively low investment efficiency in the baseline, the impact (10-year cumulative) output multipliers for public investment under domestic borrowing are about 0.3 (-0.5), while the same multiplier under external commercial borrowing correspond to 0.4 (0.6). The finding that external financing sources matter for government spending effects is related to the literature on Dutch disease associated with natural resource inflows or aid (e.g., Berg et al. (2010a), Gelb (1988), and van der Ploeg (2011)).[5] Here we formally evaluate the implications of Dutch disease on fiscal multipliers resulted from an external debt or aid financed increase in government spending.

Moreover, within external financing, we find that there are some differences between aid and commercial debt for the fiscal multiplier. In particular, aid financing produces a slightly

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[3]To restrict capital mobility, we introduce a portfolio adjustment cost in private foreign asset holdings, which captures the high costs for the private sector to obtain external finance to consume and invest (Gorodnichenko and Schnitzer (2013)). Private capital flows to sub-Saharan Africa have increased significantly from $16.1 billion to $55.2 billion in 2011, but its share in global flows remains low (Hou et al. (2013)). To model limited asset participation, we introduce a large share of hand-to-mouth households, which is typical in LICs and is important to account for the expansionary effects of fiscal policy (Mankiw (2000)).

[4]The results that the output multipliers are generally larger under external than domestic financing need some qualifications; see Section 2.

[5]Berg et al. (2010a) analyze the medium-term effects of aid-financed fiscal expansions. They distinguish between spending the aid, which is under the control of the fiscal authorities, and absorbing the aid-using the aid to finance a higher current account deficit-which is influenced by the central bank's reserves policy when access to international capital markets is limited. See also Berg et al. (2010b) for a short-term analysis.

higher output multiplier than commercial debt financing in the long run.[6] Since commercial debt financing requires larger posterior fiscal adjustments to service debt, the negative effects from higher taxes offset some of the expansionary effects of government spending.

The significance of external financing in government spending effects nonetheless diminishes when international capital mobility becomes high. The appreciated real exchange rate due to increased government external borrowing reduces the benefits of external borrowing by the private sector. Since households can adjust their portfolio with relatively low costs—a rather open capital account—they can counteract an increase in external public debt by de-leveraging their foreign borrowing. In equilibrium, the total amount of external resource available may not increase much relative to the situation of a domestically financed spending increase. Thus, the mitigation of the crowding out effect by foreign capital inflows may be small in an economy with a fairly open capital account, such as in most developed countries, while being significant in economies with limited access to international capital markets by the private sector, such as in LICs.

We also study the role of home bias in government purchases. Conventionally, models distinguishing between traded and nontraded goods (or foreign or home produced goods) often assume a high degree of home bias in government purchases (e.g., Botman and Kumar (2006) and Erceg et al. (2005)). Like developed economies, a large part of government consumption in developing countries is spent on wage bills for providing public service, classified as nontraded goods. Economists generally agree that government spending with a higher degree of home bias is more expansionary (e.g., Berg et al. (2009), Leeper et al. (2011)). Our analytical results support this conventional view with some qualifications. First, although a higher degree of home bias may reduce the crowding-out effect on private consumption of government consumption increases, it also pushes for a real exchange rate appreciation and a decline in traded output. Second, a large part of public investment in LICs is actually spent on imports of material, machinery, and skilled labor. As a result, the relatively low degree of home bias implies that public investment in LICs may not be as expansionary as advocated in developed economies.[7]

Last, we find that improvements in the efficiency associated with additional public investment spending—the so-called marginal efficiency—play an important role in determining the size and the sign of output multipliers. Problems of poor planning, execution, and management of investment projects in LICs (as reflected by the Public Investment Management Index Dabla-Norris et al. (2012) and other indicators as summarized in Brumby and Kaiser (2013)) suggest that efficiency in LICs has been low. However, as discussed in Berg et al. (2015) using a real model, precisely because of these historical inefficiencies that are reflected in capital scarcity, the return on public capital should tend to

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[6]These results about aid also extend, to an important degree, to the case of natural resource revenues. The analogy here is that both resource revenues and aid can be modelled as foreign transfers to the government.

[7]For example, a series of projects from 1990 to 2008 in Japan (Bruckner and Tuladhar (2010)) and the American Reinvestment and Recovery Act of 2009 in the U.S. were mainly used as a short-run stimulus.

be high in LICs, giving public investment a promising role to promote economic growth. In line with Berg et al., we find that improving *marginal* efficiency can raise substantially the effect of public investment increases on output in LICs, but we do so by looking at the positive and significant output multipliers in a model that accounts for Keynesian demand effects. With external financing, for instance, the 10-year output multiplier increases from 0.6 to 1.1 when efficiency rises from 0.4 to 0.8.

II. AN ANALYTICAL MODEL

We first present a simple analytical model that is sufficient to show the key roles of external financing and home bias for the effects of government spending increases on the private sector. The model highlights two effects. On the one hand, more external financing can reduce the private sector crowding out effect. On the other hand, more external financing can aggravate the negative effect on traded output, by inducing bigger real exchange rate appreciation pressures. Similar effects apply when home bias increases. To simplify the analysis, we assume no labor mobility across sectors and abstract from limited asset market participation, investment, and external and domestic debt. Monetary policy follows a forward-looking interest rate rule, and external financing is modeled as foreign aid. Later in the quantitative model we relax these assumptions.

A. Model Setup

A representative household chooses consumption (c_t), labor allocated to the non-traded good sector (l_t^N) and the traded goods sector (l_t^T), real money balances (m_t), and domestic government debt (b_t) to maximize the expected utility,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(c_t)^{1-\sigma}}{1-\sigma} - \mathfrak{a}_N \frac{\left(l_t^N\right)^{1+\psi}}{1+\psi} - \mathfrak{a}_T \frac{\left(l_t^T\right)^{1+\psi}}{1+\psi} + \frac{(m_t)^{1-\xi}}{1-\xi} \right], \tag{1}$$

subject to the budget constraint

$$c_t + b_t + m_t = w_t^N l_t^N + w_t^T l_t^T + R_{t-1} \frac{b_{t-1}}{\pi_t} + \frac{m_{t-1}}{\pi_t} + z_t + \Omega_t, \tag{2}$$

where $\mathbb{E}_0$ is the expectations operator, where expectations are assumed to be rational. $0 < \beta < 1$ is the discount factor, σ is the inverse of the intertemporal elasticity of substitution, $\mathfrak{a}_j$ for $j = N, T$ are labor disutility weights, ψ is the inverse of the Frisch elasticity of labor supply, and ξ is the inverse of the elasticity of intertemporal substitution for real money balances. $w_t^j = \frac{W_t^j}{P_t}$ for $j = N, T$ are the real wage rates paid in each sector, which differ across sectors given that there is no labor mobility, P_t is the price of consumption, R_{t-1} is the nominal interest rate, $\pi_t = \frac{P_t}{P_{t-1}}$ is the inflation rate, z_t is government transfers, and Ω_t is profits from firms in the traded and non-traded good sectors.

Households cannot access international capital markets, implying fully restricted international capital mobility.

Consumption is a CES aggregate of nontraded (c_t^N) and traded goods (c_t^T):

$$c_t = \left[\varphi^{\frac{1}{\chi}} \left(c_t^N \right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}} \left(c_t^T \right)^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}}, \tag{3}$$

where $\chi > 0$ is intratemporal elasticity of substitution, and $0 < \varphi < 1$ is the share of private spending on non-traded goods. The corresponding demand functions are

$$c_t^N = \varphi \left(p_t^N \right)^{-\chi} c_t \quad \text{and} \quad c_t^T = (1-\varphi) \left(s_t \right)^{-\chi} c_t, \tag{4}$$

and the price for composite consumption c_t, P_t, satisfies

$$1 = \frac{P_t}{P_t} = \varphi \left(p_t^N \right)^{1-\chi} + (1-\varphi) s_t^{1-\chi}, \tag{5}$$

where $s_t = \frac{S_t}{P_t}$ and $p_t^N = \frac{P_t^N}{P_t}$ are the relative prices of traded and nontraded goods. For simplicity the law of one price is assumed to hold for traded goods, and we normalize the foreign price of these goods to one.

Nontraded good firms are monopolistically competitive, facing quadratic price adjustment costs a la Rotemberg (1982). Firm i chooses the nominal price $P_t^N(i)$ and $l_t^N(i)$ to solve the profit maximization problem:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \left\{ (1+u) \left[\frac{P_t^N(i)}{P_t} y_t^N(i) - ac_t(i) \right] - w_t^N l_t^N(i) - u \left(p_t^N y_t^N - ac_t \right) \right\} \tag{6}$$

subject to the following production function and the demand constraint: $y_t^N(i) = l_t^N(i)$ and $y_t^N(i) \geq \left[\frac{P_t^N(i)}{P_t^N} \right]^{-\theta} y_t^N$. $ac_t(i) \equiv \frac{\zeta}{2} \left[\frac{P_t^N(i)}{P_{t-1}^N(i)} - 1 \right]^2 p_t^N y_t^N$ is the price adjustment costs, in which the parameter $\zeta > 0$ controls the degree of price stickines. $\theta > 1$ is the elasticity of substitution among varieties of nontraded goods, $\pi_{t+1}^N = \frac{P_{t+1}^N}{P_t^N}$, and λ_t is the marginal consumption utility of households—the owners of the firms.[8] To simplify the steady state and remove the distortions associated with monopolistic power, we assume that firms receive a subsidy rate $0 < u < 1$, which is financed by a tax levied on the entire sector. We focus on a symmetric equilibrium where $P_t^N(i) = P_t^N$, and ac_t is the corresponding adjustment costs for the entire sector.

Traded good firms, on the other hand, are perfectly competitive, and they maximize their profit $s_t y_t^T - w_t^T l_t^T$, subject to $y_t^T = l_t^T$.

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[8]Typical calibration in the NK literature has θ much bigger than one. For example, Berg et al. (2010a) set $\theta = 12$ when calibrating a NK model to a typical LIC.

LICs are usually perceived as money targeters. For now and to be able to derive analytical results, we assume that the central bank has the technology to implement a sophisticated money target rule that replicates a forward-looking interest rate rule such as[9]

$$R_t = R\mathbb{E}_t \left(\frac{\pi_{t+1}^N}{\pi^N} \right)^{\phi_\pi}, \tag{7}$$

where R is the steady-state interest rate,[10] and the objective is to target the sticky-price nontraded good inflation π_{t+1}^N, as discussed by the optimal monetary policy literature (Aoki (2001)). Also the Taylor principle applies, implying $\phi_\pi > 1$.

The government receives aid a_t^*, borrows domestically to finance non-productive government spending g_t, and issues money m_t. The government budget constraint is[11]

$$b_t + s_t a_t^* + m_t = g_t + z_t + \frac{R_{t-1}b_{t-1}}{\pi_t} + \frac{m_{t-1}}{\pi_t}. \tag{8}$$

Government spending is also a CES aggregate of traded and nontraded goods

$$g_t = \left[\left(\varphi^G \right)^{\frac{1}{\chi}} \left(g_t^N \right)^{\frac{\chi-1}{\chi}} + \left(1 - \varphi^G \right)^{\frac{1}{\chi}} \left(g_t^T \right)^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}}, \tag{9}$$

with the same intratemporal elasticity χ as in (3) and a share of public spending on non-traded goods $0 \leq \varphi^G \leq 1$. Note that we assume $\varphi^G \neq \varphi$. In what follows, we interpret φ^G as the degree of government spending home bias. Given these, the corresponding demand functions are

$$g_t^N = \varphi^G \left(\frac{p_t^N}{p_t^G} \right)^{-\chi} g_t \quad \text{and} \quad g_t^T = \left(1 - \varphi^G \right) \left(\frac{s_t}{p_t^G} \right)^{-\chi} g_t, \tag{10}$$

and the relative price of the basket (9) is

$$p_t^G = \left[\varphi^G \left(p_t^N \right)^{1-\chi} + \left(1 - \varphi^G \right) s_t^{1-\chi} \right]^{\frac{1}{1-\chi}}. \tag{11}$$

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[9]Formally, the central bank implements the following money target rule

$$m_t = c_t^{\frac{\sigma}{\xi}} \left\{ 1 - \left[RE_t \left(\frac{\pi_{t+1}^N}{\pi^N} \right)^{\phi_\pi} \right]^{-1} \right\}^{-\frac{1}{\xi}},$$

which is derived from the first-order condition for the money demand by the representative household and the money market clearing condition. See Appendix I.

[10]Steady-state values are denoted by variables without a time subscript.

[11]The subsidies and taxes mentioned above cancel out, so we do not show them in this constraint.

Each period, a fraction $0 \leq \omega \leq 1$ of government spending that exceeds the steady-state level $\Delta g_t = g_t - g$ is financed by increases in aid $\Delta a_t^* = a_t^* - a^*$, evaluated at the steady-state real exchange rate s. Then

$$\omega \Delta g_t = s \Delta a_t^*, \tag{12}$$

which implies that the fraction ω measures the extent to which government spending increases are financed with external funds. If ω is close to one (zero), then most of the government financing is external (domestic).

Government spending increases relative to the steady state follow an exogenous process such that

$$\Delta g_t = \rho \Delta g_{t-1} + \varepsilon_t, \tag{13}$$

where $0 < \rho < 1$ and ε_t are i.i.d. spending shocks. Given (12) and (13), and assuming $b_t = b \, \forall \, t$, government transfers adjust each period to satisfy the budget constraint (8).

The market clearing conditions for nontraded and traded goods are

$$y_t^N = \int_0^1 y_t^N(i) di = c_t^N + g_t^N + \frac{\zeta}{2} \left(\pi_t^N - 1 \right)^2 p_t^N y_t^N \tag{14}$$

and

$$y_t^T = c_t^T + g_t^T - a_t^*. \tag{15}$$

The absence of labor mobility across sectors implies that the equilibrium in the labor markets correspond to

$$l_t^N = \int_0^1 l_t^N(i) di \quad \text{and} \quad l_t^T = \mathfrak{l}_t^T. \tag{16}$$

Similarly there is a clearing condition that equalizes money demand balances to money supply balances.

Lastly, aggregate output in this economy is defined as

$$y_t = p^N y_t^N + s y_t^T.$$

B.   The Equilibrium and Some Simple Analytical Results for Multipliers

To simplify our analysis, we assume that, at the steady state, $g = a^* = 0$ and that the labor disutility parameters satisfy $\mathfrak{a}_N = \varphi^{-\psi}$ and $\mathfrak{a}_T = (1 - \varphi)^{-\psi}$. Also recall that we assumed the subsidy u removes the monopolistic power in the steady state. Then it is simple to show that these assumptions and the equilibrium conditions of the economy (at the steady state) imply that $\pi = \pi^N = p^N = s = p^G = w^N = w^T = y = c = mc = 1$, $R = 1/\beta$, $y^N = l^N = c^N = \varphi$ and $y^T = l^T = c^T = 1 - \varphi$. Given b and $g = a^* = 0$, transfers z adjusts to satisfy (8). Moreover, to simplify the analytical expressions for the government effects, in what follows we assume that $\sigma = \chi = 1$. This is not a restrictive assumption; it allows us to

show rather simply the *qualitative* roles of external financing and government spending home bias in the private sector adjustment, as a result of government spending shocks. In fact, it is possible to show that the main insights of the simple model still hold when $\sigma\chi \geq 1$, which is satisfied in our calibration.[12] Appendix I details the equilibrium conditions, the steady state, and the linearized system of equations.

Linearizing the equilibrium conditions that describe this economy around the steady state and manipulating them yield

$$\hat{c}_t = \mathbb{E}_t\hat{c}_{t+1} - \left(\hat{R}_t - \mathbb{E}_t\hat{\pi}_{t+1}\right), \tag{17}$$

$$\hat{\pi}_t^N = \beta\mathbb{E}_t\hat{\pi}_{t+1}^N + \left[\frac{(\theta-1)(1+\psi)}{\zeta\varphi}\right]\hat{c}_t + \left[\frac{(\theta-1)(1-\omega)\psi}{\zeta\varphi}\right]\Delta g_t, \tag{18}$$

$$\hat{R}_t = \phi_\pi\mathbb{E}_t\hat{\pi}_{t+1}^N, \tag{19}$$

$$\hat{s}_t = \hat{c}_t + \left(\frac{1-\varphi^G-\omega}{1-\varphi}\right)\left(\frac{\psi}{1+\psi}\right)\Delta g_t, \tag{20}$$

$$\hat{\pi}_t = \hat{\pi}_t^N + \left(\frac{1-\varphi}{\varphi}\right)(\hat{s}_t - \hat{s}_{t-1}), \tag{21}$$

and

$$\Delta g_t = \rho\Delta g_{t-1} + \varepsilon_t, \tag{22}$$

where we use the notation $\Delta x_t = x_t - x$ and $\hat{x}_t = \frac{\Delta x_t}{x}$.[13] Equations (17), (18), and (19) correspond to the IS curve, the NK Phillips curve for non-traded goods inflation, and the interest rate rule, respectively. Equation (20) helps pin down the dynamics of the relative price of traded goods and involves the equilibrium conditions in the labor and goods markets for traded goods, as well as the optimal conditions for households and firms regarding labor decisions for the traded good. Equations (21) and (22) are derived from the definition of inflation and the stochastic process for government spending.

Combining equations (17)-(22) further reduces the system to the following equations:

$$\hat{c}_t = \mathbb{E}_t\hat{c}_{t+1} - \Theta_\pi\mathbb{E}_t\hat{\pi}_{t+1}^N - \Theta_g\Delta g_t, \tag{23}$$

$$\hat{\pi}_t^N = \beta\mathbb{E}_t\hat{\pi}_{t+1}^N + \Gamma_c\hat{c}_t + \Gamma_g\Delta g_t, \tag{24}$$

and (22), where $\Theta_\pi = \varphi(\phi_\pi - 1)$, $\Theta_g = \frac{(1-\varphi^G-\omega)(1-\rho)\psi}{(1+\psi)}$, $\Gamma_c = \frac{(\theta-1)(1+\psi)}{\zeta\varphi}$, and $\Gamma_g = \frac{(\theta-1)(1-\omega)\psi}{\zeta\varphi}$. Using these equations, we can provide the following equilibrium definition.

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[12]Results are available upon request.

[13]Here we have to be careful manipulating the terms for government spending and foreign aid, since we assumed $g = a^* = 0$ at the steady state.

Definition 1. *An equilibrium in this economy is a sequence of stochastic processes $\{\hat{c}_t,$ $\hat{\pi}_t^N\}_{t=0}^{\infty}$ that satisfy the reduced versions of the IS curve (17) and the NK Phillips curve (18), given the stochastic process $\{\Delta g_t\}_{t=0}^{\infty}$.*

To calculate the effects of government spending and assess the role of external financing as well of government spending home bias, we need to characterize this equilibrium. The following proposition provides such characterization and states conditions under which this equilibrium is unique.

Proposition 1. *Consider the economy described by the IS curve (17) and the NK Phillips curve (18). Assume that monetary policy satisfies $\phi_\pi > 1$—the Taylor principle—and $\phi_\pi < 1 + \frac{2\zeta(1+\beta)}{(\theta-1)(1+\psi)}$. Then,*

a) there is a unique rational expectations equilibrium $\{\hat{c}_t, \hat{\pi}_t^N\}_{t=0}^{\infty}$ and, in particular,

b) the equilibrium consumption is characterized by

$$\hat{c}_t = -\frac{\psi}{1+\psi}\left[1 - \omega - \left(\frac{\mathfrak{d}}{\mathfrak{d}+\mathfrak{n}}\right)\varphi^G\right]\Delta g_t, \tag{25}$$

where $\mathfrak{d} \equiv (1-\rho)(1-\beta\rho)$ and $\mathfrak{n} \equiv \frac{(\phi_\pi-1)(1+\psi)(\theta-1)\rho}{\zeta}$.

Proof. See Appendix. *Q.E.D.*

Once the equilibrium stochastic processes for $\{\hat{c}_t, \hat{\pi}_t^N\}_{t=0}^{\infty}$ are determined, it is possible to retrieve the processes for the other macro variables. For instance, using (20), (22), and (25), we can derive the equilibrium process for the real exchange rate, which will be useful below to understand how the degrees of external financing and government spending bias affect the private consumption and sectoral output multipliers:

$$\hat{s}_t = \frac{\varphi\psi}{(1-\varphi)(1+\psi)}\left[1 - \omega - \left(\frac{\mathfrak{d}+\mathfrak{n}/\varphi}{\mathfrak{d}+\mathfrak{n}}\right)\varphi^G\right]\Delta g_t. \tag{26}$$

As expected, more external financing tends to appreciate the real exchange rate, $\frac{\partial \hat{s}_t}{\partial \omega} < 0$. Similarly, home bias increases—the government spends more on non-traded goods—generate inflationary pressures in the non-traded good sector, resulting in a real appreciation, $\frac{\partial \hat{s}_t}{\partial \varphi^G} < 0$.

Given this equilibrium characterization, it becomes straightforward to determine the fiscal multipliers. We start by analyzing the effects of government spending on private consumption, as illustrated by the following proposition.

Proposition 2. *The effect of an increase in government spending on private consumption is determined by the multiplier*

$$\mathbf{M}_c \equiv \frac{\Delta c_t}{\Delta g_t} = -\frac{\psi}{1+\psi} \left[1 - \omega - \left(\frac{\eth}{\eth + \mathfrak{n}} \right) \varphi^G \right], \tag{27}$$

implying that

a) *there is crowding-out or crowding-in,* $\mathbf{M}_c \lesseqqgtr 0$, *if* $1 - \omega \gtreqqless \left(\frac{\eth}{\eth + \mathfrak{n}} \right) \varphi^G$;

b) *more external financing increases the consumption multiplier,* $\frac{\partial \mathbf{M}_c}{\partial \omega} > 0$; *and*

c) *more government spending home bias increases the consumption multiplier,* $\frac{\partial \mathbf{M}_c}{\partial \varphi^G} > 0$.

Proof. See Appendix. *Q.E.D.*

Proposition 2 makes clear the role of external financing in determining the private consumption multiplier. As long as the degree of external financing (ω) satisfies the condition $(1 - \omega) < \frac{\eth \varphi^G}{\eth + \mathfrak{n}}$, then government spending will crowd in private consumption. In contrast, when this degree satisfies $(1 - \omega) > \frac{\eth \varphi^G}{\eth + \mathfrak{n}}$, crowding-out occurs. To grasp the intuition of these results, consider the following two extreme cases, while keeping $\varphi^G, \psi, \eth, \mathfrak{n} > 0$: (i) all financing is domestic, and (ii) all financing is external.

When all financing is domestic ($\omega = 0$), the private consumption multiplier in (27) becomes negative ($\mathbf{M}_c < 0$), implying crowding out. Two mechanisms seem to be at play in this result. First, there is an income mechanism. To fully finance the increase in spending, the government has to reduce transfers to households, which negatively affects private consumption. Second, there is a real interest rate mechanism. Given price rigidities, an increase in government spending generates substantial inflationary pressures in the non-traded good sector to which the government responds by raising nominal interest rates—recall that it follows a Taylor rule. Absent external financing, the real exchange rate can depreciate on impact—particularly when the degree of home bias is small for government purchases (see equation (26))—creating expectations of future real appreciations. As a result, the expected future overall inflation increases by less than the increases in the expected non-traded goods inflation and the nominal interest rate, resulting in an increase of the real interest rate—the difference between the nominal interest rate and expected future overall inflation—which pushes private consumption down.

With external financing ($\omega = 1$), on the other hand, the multiplier turns out to be positive ($\mathbf{M}_c > 0$), reflecting private consumption crowding in. In this case, external financing relaxes the national budget constraint, making feasible to increase both private and public consumption. The interest rate mechanism is also present here, although inducing opposite effects to those related to domestic financing: the real exchange rate appreciates—see equation (26)—and the real interest rate decreases, instead, stimulating private consumption.

Moreover, due to these mechanisms, the consumption multiplier is increasing in the degree of external financing, i.e., $\frac{\partial \mathbf{M}_c}{\partial \omega} > 0$.

A similar analysis can be conducted for the degree of government spending home bias (φ^G). The condition $(1 - \omega) \gtreqqless \frac{\partial \varphi^G}{\partial + \mathfrak{n}}$ in Proposition 2 suggests that, given other parameters, sufficient home bias can actually switch the private consumption effects from crowding out to crowding in. More home bias—increasing φ^G—means a greater demand for non-traded goods and therefore expectations of higher non-traded goods inflation. Since the real exchange rate appreciates on impact—see equation (26)—generating expectations of future depreciations, the expected future overall inflation can increase by more than the increase in the expected future non-traded goods inflation. It is then feasible that the increase in the nominal interest rate—which responds to the expected future non-traded goods inflation, via the Taylor rule—may be insufficient to offset the increase in expected future overall inflation. If this occurs, the real interest rate declines stimulating private consumption (crowding-in effect). In contrast, without home bias ($\varphi^G = 0$), non-traded goods inflation pressures are almost nil, and the real exchange rate depreciates on impact, inducing expectations of future appreciations. These effects imply a very small change of the nominal interest rate and a decline in expected future overall inflation. As a result, the real interest increases, affecting negatively private consumption (crowding-out effect). As with the degree of external financing, the consumption multiplier is also increasing in the degree of home bias, i.e., $\frac{\partial \mathbf{M}_c}{\partial \varphi^G} > 0$.

The degrees of external financing and home bias can also shape the impact of government spending increases on traded and non-traded output. The following proposition formalizes this statement by deriving the sectoral output multipliers.

Proposition 3. *The effects of an increase in government spending on traded output and non-traded output are determined by the multipliers*

$$\mathbf{M}_{y^T} \equiv \frac{\Delta y_t^T}{\Delta g_t} = \frac{1}{1 + \psi} \left(1 - \omega - \varphi^G \right) \quad and \quad \mathbf{M}_{y^N} \equiv \frac{\Delta y_t^N}{\Delta g_t} = \left[\frac{\partial + \mathfrak{n}/(1 + \psi)}{\partial + \mathfrak{n}} \right] \varphi^G, \quad (28)$$

implying that

a) traded output can decrease or increase, $\mathbf{M}_{y^T} \lesseqqgtr 0$, if $\omega + \varphi^G \gtreqqless 1$;

b) more external financing or government spending home bias decrease the traded output multiplier, $\frac{\partial \mathbf{M}_{y^T}}{\partial \omega} < 0$ and $\frac{\partial \mathbf{M}_{y^T}}{\partial \varphi^G} < 0$; and

c) non-traded output can increase, $\mathbf{M}_{y^N} \geq 0$, with a multiplier that increases with a higher degree of home bias in government spending, $\frac{\partial \mathbf{M}_{y^N}}{\partial \varphi^G} > 0$.

Proof. See Appendix. *Q.E.D.*

Proposition 3 shows that in determining the sign of the traded-output multiplier, the degree of external financing plays a crucial role. Extreme cases are, once more, illustrative. When government spending increases are fully covered by external financing ($\omega = 1$), the traded-output multiplier becomes negative ($\mathrm{M}_{y^T} < 0$), provided that some of this spending falls on non-traded goods ($\varphi^G > 0$). This is not surprising. As discussed above, more external financing tends to appreciate the real exchange rate, which affects negatively the traded good sector competitiveness. Moreover, since prices are flexible in this sector, there are no demand-driven effects that can stimulate traded output. On the other extreme, when there is no external financing ($\omega = 0$), the multiplier can be positive ($\mathrm{M}_{y^T} > 0$), since the real exchange rate appreciates *less* or even depreciates. The mechanism behind these extreme cases also helps explain why the traded-output multiplier is decreasing in the degree of external financing, i.e., $\frac{\partial \mathrm{M}_{y^T}}{\partial \omega} < 0$.

Similarly, the degree of government spending home bias may determine the sign of the traded-output multiplier. To see this, imagine that there is no public spending on non-traded goods ($\varphi^G = 0$), while keeping some external financing ($\omega > 0$). Then the traded-output multiplier is clearly positive ($\mathrm{M}_{y^T} > 0$). Without home bias, spending increases can lead to real depreciations, which in turn stimulate traded output. In contrast, if all public spending falls on non-traded goods ($\varphi^G = 1$), significant real appreciations can occur, and traded output will then fall ($\mathrm{M}_{y^T} < 0$). As with external financing, the traded-output multiplier decreases with home bias, i.e., $\frac{\partial \mathrm{M}_{y^T}}{\partial \varphi^G} < 0$.

As expected, home bias affects positively the non-traded output multiplier. Given price rigidities, output is demand-determined in the non-traded sector. Therefore, more public spending on non-traded goods directly translates into more non-traded output. And the higher the home bias is, the higher the non-traded output multiplier will be, i.e., $\frac{\partial \mathrm{M}_{y^N}}{\partial \varphi^G} > 0$. Interestingly, in our simple model, the degree of external financing does not affect this multiplier. This seems to be driven by our assumption of imperfect labor mobility. In fact, with perfect labor mobility across sectors, it is possible to show that the non-traded output multiplier will depend on the degree of external financing.[14]

Our analysis in this simple model has underscored the importance of the degrees of external financing and home bias in the responses of the private sector to a government spending increase. More external financing or home bias can reduce the crowding out effect on private consumption (or even generate crowding in), increasing the private consumption multiplier; but they also tend to appreciate the real exchange rate, discouraging traded output and, therefore, reducing the traded output multiplier. These are important insights. However, this simple model has ignored many other features of LICs that may be relevant for the fiscal multiplier analysis. In the next section, we lay out a more realistic model that accommodates several of these important features, to assess quantitatively the multipliers associated with both government consumption and public investment shocks.

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[14]Results are available upon request.

III. A QUANTITATIVE MODEL

The framework, adapted from Berg et al. (2010a), is a small open, NK model. The quantitative model introduces additional important features of LICs, including 1) two types of households—savers and non-savers, 2) some labor mobility across sectors, 3) a distinction between government consumption and public investment, which can be inefficient, 4) limited access to international financial markets by households, 5) government's access to external government debt, and 6) money targeting. Variables and parameters here share the same definition as those used in Section II.

A. Households

The economy is populated by two types of households where a fraction f are savers (a) and a fraction $1 - f$ are hand-to-mouth (h). Savers have access to financial and capital markets, while the hand-to-mouth households are liquidity constrained.

1. Savers

A representative saver chooses consumption (c_t^a), the real money balance (m_t^a), labor (l_t^a), investment ($i_t^{N,a}$ and $i_t^{T,a}$), capital ($k_t^{N,a}$ and $k_t^{T,a}$), domestic government debt ($b_t^{d,a}$), and external debt ($b_t^{h*,a}$) to maximize the expected utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(c_t^a)^{1-\sigma}}{1-\sigma} - \frac{(l_t^a)^{1+\psi}}{1+\psi} + \frac{(m_t^a)^{1-\xi}}{1-\xi} \right], \tag{29}$$

subject to the following budget constraint:

$$c_t^a + m_t^a + i_t^{N,a} + i_t^{T,a} + b_t^{d,a} + s_t R^* \frac{b_{t-1}^{h*,a}}{\pi^*} + ac_t^{b,a} + ac_t^{i,a}$$

$$= (1 - \tau_t) \left(w_t l_t^a + r_t^N k_{t-1}^{N,a} + r_t^T k_{t-1}^{T,a} \right) + \frac{R_{t-1} b_{t-1}^{d,a}}{\pi_t} + s_t b_t^{h*,a} + \frac{m_{t-1}^a}{\pi_t} + s_t rm^* + z + \Omega_t^a. \tag{30}$$

Domestic government debt $b_t^{d,a}$ pays a nominal rate of R_t at $t + 1$. Savers can borrow (lend) externally by issuing $b_t^{h*,a} > 0 \, (< 0)$ in units of foreign goods. R^* in the nominal interest rate demanded by foreign creditors, and π^* is foreign inflation, both assumed to be constant. Following Schmitt-Grohé and Uribe (2003), changing foreign liabilities is subject to portfolio adjustment costs $ac_t^{b,a} \equiv s_t \frac{v b^{h*,a}}{2} \left(\frac{b_t^{h*,a}}{b^{h*,a}} - 1 \right)^2$, where v governs capital account openness in the private sector. These costs represent the financial costs that prevent LIC

households from engaging in a higher degree of consumption smoothing through borrowing and lending in international financial markets. A tax rate τ_t is levied on labor and capital income. Foreign remittances rm^* are assumed to be constant.[15]

We assume that capital is sector specific, with returns r_t^N and r_t^T, and subject to adjustment costs $ac_t^{i,a} \equiv \frac{\kappa}{2}\left[\left(\frac{i_t^{N,a}}{k_{t-1}^{N,a}} - \delta\right)^2 k_{t-1}^{N,a} + \left(\frac{i_t^{T,a}}{k_{t-1}^{T,a}} - \delta\right)^2 k_{t-1}^{T,a}\right]$. Capital in each sector evolves according to the law of motion

$$k_t^{j,a} = (1-\delta)k_{t-1}^{j,a} + i_t^{j,a}, \quad j \in \{N,T\}, \tag{31}$$

where δ is the depreciation rate and $i_t^{j,a}$ is investment. Total investment by savers is $i_t^a = i_t^{N,a} + i_t^{T,a}$.

Consumption and investment are CES aggregates of nontraded and traded goods as in (3), with the same elasticity of substitution χ and degree of home bias φ. The implied unit price of consumption c_t is the same as in (5). As in the analytical model, nontraded goods are produced by a continuum of monopolistically competitive firms. Nontraded consumption varieties are also aggregated by a CES basket, with the elasticity of substitution between varieties denoted by θ.

Households supply labor to both sectors. Savers' total labor supply is

$$l_t^a = \left[(\varphi^l)^{-\frac{1}{\chi^l}}\left(l_t^{a,N}\right)^{\frac{1+\chi^l}{\chi^l}} + (1-\varphi^l)^{-\frac{1}{\chi^l}}\left(l_t^{a,T}\right)^{\frac{1+\chi^l}{\chi^l}}\right]^{\frac{\chi^l}{1+\chi^l}}, \tag{32}$$

where φ^l is the steady-state share of labor in the nontraded good sector and $\chi^l > 0$ is the elasticity of substitution between the labor used in each sector. Unlike the analytical model, labor can move across the sectors but is not perfectly mobile. From the cost minimization problem, the aggregate real wage index is derived as

$$w_t = \left[\varphi^l\left(w_t^N\right)^{1+\chi^l} + (1-\varphi^l)\left(w_t^T\right)^{1+\chi^l}\right]^{\frac{1}{1+\chi^l}}, \tag{33}$$

where w_t^N and w_t^T are the real wage rate of each sector.

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[15]While not analyzed here, remittances help pin down the foreign debt of savers in the steady state.

2. Hand-to-Mouth Households

The hand-to-mouth households have an inelastic labor supply ($l_t^h = l^h \; \forall \; t$)[16] and consume all the disposable income every period as determined by the budget constraint

$$c_t^h = (1 - \tau_t) \, w_t l^h + s_t r m^* + z. \tag{34}$$

B. Firms

Like the analytical model, nontraded good firms are monopolistically competitive. Since manufacturing in LICs often concentrates on resource-based and low-technology production, traded good firms are assumed to be perfectly competitive.[17]

1. Nontraded Good Sector

The technology of the nontraded goods producer $i \in [0, 1]$ is

$$y_t^N(i) = z^N \left[k_{t-1}^N(i)\right]^{1-\alpha^N} \left[l_t^N(i)\right]^{\alpha^N} \left(k_{t-1}^G\right)^{\alpha^G}, \tag{35}$$

where z^N is the sector-specific total factor productivity (TFP), and k_{t-1}^G is public capital with an output elasticity of α^G. Aggregating all nontraded goods $y_t^N = \left[\int_0^1 y_t^N(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$ and solving the profit maximization problem yield the demand function for good i,

$$y_t^N(i) = \left[\frac{P_t^N(i)}{P_t^N}\right]^{-\theta} y_t^N. \tag{36}$$

A nontraded good producer i chooses the price of the variety it produces, labor and capital to maximize its net present-value profits,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \times \underbrace{\left\{(1+u)\,(1-\iota)\left[p_t^N(i)y_t^N(i) - ac_t^p(i)\right] - w_t^N l_t^N(i) - r_t^N k_{t-1}^N(i) + \mathfrak{st}_t\right\}}_{\equiv \Omega_t^N(i), \text{ dividends}}, \tag{37}$$

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[16]There are few estimates available for the labor elasticity in LICs. Goldberg (forthcoming) uses a field experiment to estimate the wage elasticity of employment in the day labor market in rural Malawi and obtains a low labor supply elasticity of 0.15. For simplicity, we make an extreme assumption that labor supply is inelastic for hand-to-mouth households.

[17]Based on data from 2000 to 2009, 74.5 percent of value added in total manufacturing is resource-based and low-technology production in Africa (UNIDO and UNCTAD (2011)).

with $\mathfrak{st}_t = (\iota - u + \iota u)\left(p_t^N y_t^N - ac_t^p\right)$ and subject to the production function (35) and the demand function (36). As in the simple model, there are price adjustment costs $ac_t^p(i) \equiv \frac{\varsigma}{2}\left[\frac{\pi_t^N(i)}{\pi_{t-1}^N} - 1\right]^2 p_t^N y_t^N$, where total costs are $ac_t^p \equiv \int_0^1 ac_t^p(i)di$. Similarly, total nontraded output and dividends are defined as $y_t^N = \int_0^1 y_t^N(i)di$, and $\Omega_t^N = \int_0^1 \Omega_t^N(i)di$. To capture additional distortions in production (other than the explicit tax τ on factor income), we introduce an implicit cost (tax) ι. Unlike income taxes, the revenue collected by ι does not enter the government budget and remains in the private sector. For simplicity, we assume the implicit cost is rebated back to firms (hence savers) in a lump-sum fashion.[18] Also, as before, we introduce a subsidy u such that in the steady state the markup due to monopolistic power is zero.

2. Traded Good Sector

A representative traded good firm chooses labor and capital to maximize periodic profits[19]

$$\Omega_t^T \equiv (1 - \iota)\, s_t \left[z^T\left(k_{t-1}^T\right)^{1-\alpha^T}\left(l_t^T\right)^{\alpha^T}\left(k_{t-1}^G\right)^{\alpha^G}\right] - w_t^T l_t^T - r_t^T k_{t-1}^T + \iota s_t y_t^T. \tag{38}$$

Total dividends from firms are $\Omega_t = \Omega_t^N + \Omega_t^T$, and total real output produced in the economy at period t is $y_t = p_t^N y_t^N + s_t y_t^T$.

C. Government

Each period the government receives taxes and foreign aid (a_t^*), issues domestic and foreign debt (b_t^d and b_t^{g*}), and generates seigniorage revenue. Total expenditures include government consumption (g_t^C), public investment (g_t^I), transfers to households, and debt services. The flow budget constraint is

$$tax_t + b_t^d + s_t b_t^{g*} + s_t a_t^* + m_t = p_t^G\left(g_t^C + g_t^I\right) + z + \frac{R_{t-1} b_{t-1}^d}{\pi_t} + s_t \frac{R^* b_{t-1}^{g*}}{\pi^*} + \frac{m_{t-1}}{\pi_t}, \tag{39}$$

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[18]The implicit cost is a shortcut to rationalize why given the high marginal return to capital implied by capital scarcity in LICs, we do not observe a higher investment to output ratio in the steady state.

[19]Following Berg et al. (2010a), we could also magnify Dutch disease effects by incorporating a learning-by-doing (LBD) externality into the traded sector: a decline in the traded sector will impose an economic cost through lost total-factor productivity. We leave this extension for future research.

where $tax_t = \tau_t \left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T \right)$. We assume that the government faces the same nominal interest rate R^* as savers when borrowing externally.[20]

Government consumption and public investment are CES baskets of traded and nontraded goods as in (9). To capture low investment efficiency in LICs, we assume that one dollar of investment expenditure can deliver less than one dollar of public capital:[21]

$$k_t^G = \left(1 - \delta^G\right) k_{t-1}^G + \epsilon g_t^I, \quad 0 \leq \epsilon \leq 1, \tag{40}$$

where ϵ measures this inefficiency.[22] Also, government consumption and investment follow the exogenous processes:[23]

$$\log \frac{g_t^j}{g^j} = \rho_G \log \frac{g_{t-1}^j}{g^j} + \varepsilon_t^j, \quad j \in \{C, I\}. \tag{41}$$

Three financing methods are considered: domestic debt, external debt, and aid.[24] When one of the three is employed to finance a spending increase, the other two are set to their steady-state levels. For example, when domestic debt is used for financing, b_t^d is endogenously determined by the government budget constraint (39), while $b_t^{g*} = b^{g*}, a_t^* = a^* \ \forall \ t$. With domestic or external debt financing, total government debt rises, which triggers gradual fiscal adjustments. We assume the tax rate adjusts to maintain debt sustainability.

$$\log \frac{\tau_t}{\tau} = \rho_\tau \log \frac{\tau_{t-1}}{\tau} + \gamma \log \frac{s_{t-1}^b}{s^b}, \quad \gamma \geq 0 \tag{42}$$

where $s_{t-1}^b = \frac{b_{t-1}^d + s_{t-1} b_{t-1}^{g*}}{y_{t-1}}$.[25]

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[20]Our specification has a constant risk premium. Empirically, the premium rises when a government becomes more indebted (e.g., Akitoby and Stratmann (2008)), but the relationship tends to be non-linear. See Bi et al. (2014), which analyzes government spending effects for developing countries in a DSGE model with endogenous risk premia.

[21]See Pritchett (2000).

[22]Efficiency may depend on the source of financing. For example, disbursements of Chinese loans in sub-Saharan Africa are often subject to relatively strict conditions, implying that investment efficiency could be higher under external financing than under domestic financing. We leave these issues for future research.

[23]We model these spending policies exogenously. In future research, we can investigate optimal fiscal policy.

[24]One common financing source in LICs is external concessional borrowing, which has a subsidized interest rate and a long maturity period. While not analyzed here, the effects of government spending financed by concessional borrowing would fall between the results with external (commercial) debt and aid financing.

[25]Alternatively, government spending or transfers can also adjust to stabilize debt growth. In an environment with a large share of the hand-to-mouth, the effects of transfer adjustments are similar to income tax rates. Also, we do not consider a spending reversal here, and thus do not allow government consumption or investment to respond to debt.

Given shallow financial markets, many central banks in LICs target money in practice. To capture this, we assume the government follows a money growth rule where nominal reserve money grows at a constant rate ϕ. Hence real money balance follows the process

$$m_t = \phi \frac{m_{t-1}}{\pi_t}. {}^{26} \tag{43}$$

D. Aggregation and Market Clearing

With two types of households, aggregate consumption and labor are computed as follows.

$$x_t = f x_t^a + (1-f) x_t^h, \quad x \in \left\{ c, c^N, c^T, l, l^N, l^T \right\}. \tag{44}$$

Since only savers have access to asset and capital markets, aggregate real money balance, investment, capital, debt, and dividends are computed as

$$x_t = f x_t^a, \quad x \in \left\{ m, i^N, i^T, i, k^N, k^T, b^d, b^{h*}, \Omega, ac^b, ac^i \right\}. \tag{45}$$

Last, the market clearing condition for nontraded goods is given by

$$y_t^N = (p_t^N)^{-\chi} \left[\varphi \left(c_t + i_t + ac_t^i + ac_t^b + ac_t^p \right) + \varphi^G (p_t^G)^{\chi} g_t \right]; \tag{46}$$

while the balance of payment condition corresponds to

$$\underbrace{c_t + i_t + p_t^G \left(g_t^C + g_t^I \right) + ac_t^i + ac_t^b + ac_t^p + s_t \left(R^* - 1 \right) \frac{b_{t-1}^{h*} + b_{t-1}^{g*}}{\pi^*} - y_t - s_t rm^*}_{=CA_t^d, \text{ current account deficits}}$$

$$= s_t \left(a_t^* + b_t^{h*} + b_t^{g*} - \frac{b_{t-1}^{h*} + b_{t-1}^{g*}}{\pi^*} \right). \tag{47}$$

IV. SOLUTION AND CALIBRATION OF THE QUANTITATIVE MODEL

We log-linearize the equilibrium system and use Sims's (2001) algorithm for solving linear rational expectations models. The quantitative model is at a quarterly frequency and

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[26]An alternative rule that allows the money growth rate to target inflation can be specified. This alternative rule, with a reasonable response magnitude to inflation, does not change the results presented here qualitatively.

calibrated to an average LIC, based on the data of 45 SSA country from 2005 to 2012.[27]
Table 1 summarizes parameter values in the baseline calibration.[28]

Based on the estimates by Ogaki et al. (1996) for developing countries, the intertemporal
elasticity of substitution is set to 0.34, implying $\sigma = 2.94$. This suggests that consumption
decisions are less on intertemporal smoothing considerations relative to households in
developed countries with the typical values $\sigma = 1$ or 2. Without empirical evidence for the
Frisch labor elasticity for SSA economies, we calibrate $\psi = 1$ for savers. Together with
hand-to-mouth households' inelastic labor supply, the average Frisch labor elasticity is 0.25.
The inverse of the intertemporal elasticity of real money balances ($\xi = 3.1$) is endogenously
determined by the money demand equation, given the quarterly nominal interest rate and the
money aggregate to output ratio.

The discount factor $\beta = 0.98$ is consistent with an annual real interest rate of 8 percent. The
share of savers f is set to 0.25. Ardic et al. (2013) report that about 25 percent of the poor
population has a bank account. Based on 2011 data, Demirguc-Kunt and Klapper (2012)
compute that on average about 24 percent of adults in SSA and 23 percent of people living
under $2 a day have an account in a formal financial institution.[29]

The degree of home bias in private consumption and investment φ is set to 0.6 and in
government purchases φ^G is 0.7. Since distribution costs can be high in rural Africa, we
assume a slightly higher share than the typical value of 0.5 (Burstein et al. (2005)). We
follow the convention to assume a higher degree of home bias in government purchases
because a large part of government spending goes to pay civil service. Together with
calibrated private consumption and investment shares to output in data (see Table 1), the
model implies the value added by nontraded output is 65 percent of GDP in the steady state.

For the elasticity of substitution between traded and nontraded goods, we set $\chi = 0.44$,
following Stockman and Tesar's (1995) estimate based on a sample including developing and
developed countries. The labor income shares in nontraded and traded production are set to
$\alpha^N = 0.45$ and $\alpha^T = 0.6$, following the calibration by Buffie et al. (2012) for an average
African economy. We assume the share of labor working in the nontraded good sector equals

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[27]Most SSA countries are LICs or lower middle-income countries. We exclude South Sudan for non-existent
data before 2011. The data used to calibrate the initial steady state are the average ratios of the following
variables to GDP: private consumption expenditure, private gross fixed capital formation, balance on goods and
services, public consumption expenditure, percent changes in consumer prices, general government revenue
(grants and taxes), broad money, and general government gross debt (all downloaded from the database of the
World Economic Outlook, International Monetary Fund (2013)).

[28]A separate appendix that details the optimality conditions, the steady state, and the log-linearized system, is
available upon request.

[29]A wide variation in the degree of financial development exists across SSA countries. Based on the estimates
using the Global Findex Database, the percentage of adults with an account in a formal financial institution in
SSA is 45 percent in the richest quintile countries and only 12 percent in the poorest quintile (Demirguc-Kunt
and Klapper (2012)).

the ratio of of its labor income to total labor income in the economy, which implies that $\varphi^l = 0.58$. Consistent with the common value used for the depreciation rate of private capital, $\delta = 0.025$, implying an annual depreciation rate of 10 percent.

The elasticity of substitution between variety of goods is set to $\theta = 6$, so a steady-state markup in the goods market is 20 percent, as calibrated in Galí and Monacelli (2005) for a small open economy. To remove the monopolistic power in the steady state, this implies $u = 0.2$ for the subsidy rate provided to nontraded good firms. The intra-temporal elasticity of substitution between labor of the two sectors χ^l is set to 0.6. Horvath (2000) estimates this elasticity to be 1 using the U.S. sectoral data. Artuc et al. (2013) estimate that on average labor mobility costs are 4.26 times of annual wages in SSA countries, and only 2.41 times in developed countries. Thus, compared to developed countries we assume less mobility in our model. The capital adjustment cost parameter κ is set to 1.4, based on developing country estimates from similar specifications (Mexico, Aguiar and Gopinath (2007)). For price rigidities, we assume that, on average, the price for nontraded goods is rigid for one year, implying $\zeta = 56.6$.[30]

Public capital is assumed to consist mostly of infrastructure, which has a lower depreciation rate than equipment. We assume $\delta^G = 0.0125$, which implies an annual rate of 5 percent, much lower than the calibrated 10 percent for private capital. To calibrate public investment efficiency, we turn to the estimates by Hurlin and Arestoff (2010) for Colombia and Mexico. They obtain a lower-bound estimate of 0.38 for the two developing countries. Our baseline calibration assumes $\epsilon = 0.4$. To see the effects of increasing investment efficiency on multipliers, the analysis is also performed under the higher marginal efficiency of 0.8. The public investment-to-output ratio is calibrated to be 0.045 to yield an annual public capital-output ratio of 0.36 in the steady state.[31] The output elasticity with respect to public capital is selected to be $\alpha^G = 0.11$ such that the annual net rate of return to public capital is 25.6 percent in the steady state, close to the median return of 24 percent for World Bank projects in 2008 (International Bank for Reconstruction and Development and the World Bank (2010)).

The model has the income tax rate as a fiscal adjustment instrument. The adjustment magnitude, $\gamma = 0.03$, is chosen such that a minimal but sufficient adjustment is implemented to ensure debt sustainability. The steady state is calibrated to have a public debt-to-annual output ratio at 33 percent, the 2005-12 average of the general government debt to GDP ratio of the SSA country (see footnote 27), among which 70 percent is assumed to be external public debt.

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[30]To calibrate ζ, we resort to the equivalence of Calvo and Rotemberg price setting as derived in Ascari and Rossi (2012).

[31]In the data, the average ratio of public gross fixed capital formation to GDP for SSA countries from 2005 to 2012 is 8.1 percent (International Monetary Fund (2013)). However, assuming such a level of public investment in the steady state would yield a relatively high stock of public capital (65 percent of GDP), inconsistent with the reality of capital scarcity in LICs. Kamps (2004) estimates that the average government net capital stock as a percentage of GDP is 51.4 percent for OECD countries in 2000.

For the degree of capital account openness in the private sector, the baseline assumes limited international capital mobility by setting $v = 10$. Our sensitivity analysis also explores less restricted mobility under smaller v's.

V. GOVERNMENT CONSUMPTION EFFECTS

We analyze the effects of a government consumption shock and a public investment shock separately under three financing sources: domestic debt, external debt, and aid. A present-value, cumulative multiplier at k quarters after the shock is computed for both types of spending, as

$$M^x(k) = \frac{\sum_{s=0}^{k} \left(\prod_{j=0}^{s} r_j^{-1} \right) \triangle x_s}{\sum_{s=0}^{k} \left(\prod_{j=0}^{s} r_j^{-1} \right) \triangle p_s^G g_s^{\mathfrak{m}}}, \quad x \in \left\{ y, y^N, y^T, c, i, tb \right\}, \; \mathfrak{m} \in \{C, I\} \quad (48)$$

where $\triangle$ denotes level changes from the steady state, $r_0 \equiv 1$, $r_t \equiv \mathbb{E}_t \frac{R_t}{\pi_{t+1}}$ is the real interest rate, and $tb_t = y_t - c_t - i_t - p_t^G g_t$ is the trade balance. Tables 2 and 3 report the government consumption and public investment multipliers under the baseline calibration.

A. Domestic vs. External Financing Sources

Figure 1 compares the impulse responses to a government consumption increase with domestic (dotted-dashed lines), external debt (solid lines), and aid (dashed lines) financing under the baseline calibration. The size of the government consumption shock is 1 percent of steady-state output at time zero and decreases overtime according to the AR(1) process in (41).

1. Domestic Financing

When international capital mobility is limited ($v = 10$), domestic financing produces effects similar to those implied by typical neoclassical or NK models for a closed economy (e.g., Baxter and King (1993), Forni et al. (2009), and Leeper et al. (2010)). Higher government consumption financed by domestic debt triggers a negative wealth effect among forward-looking savers as they anticipate higher future taxes to pay for the spending increase. The negative wealth effect drives up savers' labor (hence aggregate labor due to the hand-to-mouth's inelastic labor supply) and decreases consumption.

In contrast, hand-to-mouth households have the opposite consumption response for the first two quarters. Their positive consumption response is due to additional income from the government consumption increase. The short-run price rigidity prevents nontraded good prices from rising fully, raising demand pressure on nontraded goods due to the government consumption increase. The real wage rate in the nontraded good sector increases initially, drawing labor to nontraded production. A higher wage rate in turn raises the hand-to-mouth's income and thus supports higher consumption. Later, as higher government debt triggers tax rate increases and nominal rigidities dissipate, hand-to-mouth's disposable income and consumption fall accordingly.

With domestic debt financing, the standard crowding-out effects associated with government spending prevail. This is reminiscent of the results in the simple model. But here the crowding out effect is also on private investment.[32] As the government increases domestic borrowing to finance its consumption increase, savers demand a higher interest rate to hold government debt. A higher interest rate then crowds out private investment. In later years, although investment declines become smaller, investment remains below the steady-state level because the income tax rate is persistently higher to maintain debt sustainability (see Figure 1).[33]

On the external side, the government's relatively high demand for nontraded goods pushes higher up the relative price of nontraded goods, appreciating the real exchange rate. The real appreciation, however, produces little movement in the current account. Although the real appreciation reduces the competitiveness of the traded good sector, weak domestic demand, as shown by the negative multipliers of consumption and investment (the top panel of Table 2), also reduces demand for traded goods in the private sector, leaving the current account roughly unchanged.

With domestic debt financing, the output multiplier on impact is 0.4 and falls to -0.4 five years after the initial shock (Table 2). The small output multiplier may seem surprising despite that three quarters of the households are hand-to-mouth, whose consumption rises substantially in the short run. In addition to the crowding-out effects on investment and consumption, government spending in an open economy has an additional leak in its expansionary effects, as part of the demand increase in government purchases can be met by imports. When we assume that government purchases consist of almost all nontraded goods, the impact multiplier under domestic financing (not shown in the table) rises from 0.4 to 0.7 due to a much higher multiplier for nontraded output.[34]

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[32]The result of investment crowding out needs not occur if the government spending is on productive investment, as shown in the literature (e.g., Baxter and King (1993) and Traum and Yang (2015)). The effects of public investment are to be analyzed in Section 6.

[33]The investment dynamics in the medium and long run depend crucially on the speed of fiscal adjustment. If γ in (42) is bigger, implying more aggressive adjustments, investment will fall more in earlier periods but return to the steady-state level sooner.

[34]In this excise of a high degree of home bias, we set $\varphi^G = 0.999$.

2. External Financing: Debt

Compared to domestic financing, Figure 1 shows that government consumption effects differ substantially with external debt financing especially in the short run. The very different responses in consumption and traded output between external and domestic financing are consistent with the finding using the analytical model.

Large inflows of foreign exchange due to higher external borrowing appreciate the real exchange rate much more than with domestic financing. The more appreciated real exchange rate reduces traded output more in the first three years. The multiplier for traded output is -0.3 on impact, compared to 0.1 with domestic financing. While our assumption that traded good firms do not have market power is extreme, the concentration of low-level technology manufacturing in LICs suggests that traded output can be quite susceptible to exchange rate fluctuations.[35] In contrast to the little changes in the current account with domestic financing, trade deficits rise substantially with external debt financing. The much appreciated real exchange rate induces substitution of traded goods in private demand for nontraded goods, worsening the trade balance. The multiplier of the trade balance is -0.5 on impact, compared to almost zero with domestic financing.

Despite a much negative traded output multiplier with external debt financing, the impact output multiplier is slightly bigger than with domestic financing—0.43 versus 0.39. Moreover, the five-year output multiplier becomes positive—0.2 in comparison to -0.4 with domestic financing. The expansionary effect of government consumption with external debt financing partly comes from less negative investment and more positive consumption responses. As explained in the simple model, external financing expands the resource envelope for the domestic economy at least in the short run. Thus, it relieves the severe crowding-out effect observed earlier with domestic financing. Investment in the non-traded good sector (not shown in the figure) even turns positive for the first two years due to higher nontraded good demand. The cumulative investment multiplier is almost zero five years after the shock, compared to -0.8 with domestic financing. Due to the much more positive consumption responses of the hand-to-mouth, the consumption multiplier on impact rises from 0.1 with domestic financing to 0.5 with external debt financing.

As the government spending effect wanes over time, the effects of fiscal adjustments dominate in later years. Like domestic debt financing, external borrowing also triggers higher income tax rates, exerting a negative influence on investment and nontraded output. Complying with debt service payments to foreign creditors leads to a small real depreciation later on, raising the competitiveness of the traded good sector and its output.

Overall, government consumption is more expansionary with external than with domestic debt financing. A few caveats, however, are worth noting. Our analysis assumes a constant

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[35]Rodrik (2008) finds empirical support that the real exchange rate movements plays an important role in traded good production of developing countries.

risk premium regardless of the debt level. Also, the thought experiment has the spending shock occur when the economy is at the steady state with relatively low government debt. When an economy is at a high-debt state, a debt-financed spending increase can prompt foreign creditors to demand a much higher premium. The magnitude of fiscal adjustments then has to be bigger to maintain debt sustainability. Under those circumstances, the negative effects of fiscal adjustments on output can offset further the expansionary effects of government consumption increases.[36]

3.   External Financing: Aid

Figure 1 shows that the fiscal effects with aid financing (dashed lines) are similar to those with external debt financing (dotted-dashed lines) in the short run. The main difference between these two financing methods lies in the implied fiscal adjustments. Aid financing does not require subsequent repayments. Thus, the tax rate remains at the steady-state level. As savers do not anticipate higher future taxes, their consumption does not change much. In later years, investment with aid financing outperforms that with external debt financing because the income tax rate is lower. Among the three financing methods, aid financing is the best in terms of output performance in the longer horizon, since persistent higher tax rates with debt financing keep output below the steady state.

Like external debt, aid financing leads to substantial real exchange rate appreciation, lowering traded output—a mechanism that is familiar from the simple model. Spending aid domestically often raises the well-known concern of Dutch disease. Empirically, Rajan and Subramanian (2011) find that traded production (manufacturing) is negatively affected by aid inflows, as implied here by an aid-financed spending increase. In our model, the loss of traded output follows from the real exchange rate appreciation that forces reallocation of production factors from the traded to nontraded good sector to cope with higher nontraded good demand. If the loss of traded output is persistent, Dutch disease effects can prevail and the output multipliers will be much smaller.[37]

B.   Sensitivity on International Capital Mobility

So far, we have shown that the degree of external financing matters for government spending effects in the environment with limited international capital mobility. The importance of accounting for financing sources, however, largely *vanishes* when international capital mobility becomes high.

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[36]See Bi et al. (2014) for government spending effects when an economy is near its fiscal limits.

[37]To capture this, we could follow Berg et al. (2010a), who capture Dutch disease effects by assuming learning-by-doing externalities in TFP of traded good production.

Figure 2 compares impulse responses for a government consumption shock (with the same size in Figure 1) with external debt financing across various degrees of capital mobility: $v = 10$ (baseline), $v = 0.001$, and $v = 0.0001$ representing the scenario of a nearly completely open capital account. With higher capital mobility, households counteract the government's external borrowing, and the economy as a whole borrows less externally relative to limited mobility. An initial real appreciation from rising external public debt discourages households from borrowing externally because the marginal benefit of additional borrowing in units of local goods decreases. Since fewer resources are available for the domestic economy, government consumption with external financing has similar crowding-out effects as those with domestic debt financing.

VI. PUBLIC INVESTMENT EFFECTS

Figure 3 plots the impulse responses with the three financing methods under the baseline calibration for a public investment increase equal to 1 percent of steady-state output at time zero. The analysis here focuses on the role of investment efficiency and the degree of home bias in the multipliers for public investment.

Public investment spending differs from government consumption as it accumulates to public capital used in production and therefore increases the marginal productivity of private inputs. Within each financing method, the multipliers for public investment are slightly smaller in the short run but substantially bigger in later years as productive public capital builds up over time. The negative wealth effect triggered by a government investment increase—like the one discussed for a government consumption shock—is weakened because households expect more public capital, which would increase future production and income. Hence, consumption is more positive, crowding out private investment further compared to the effects of a government consumption increase. Moreover, since the productivity of private capital and labor increases, output of both sectors and hence consumption are higher in later years, relative to those for a government consumption shock. Despite a higher income tax rate, investment does not fall below the steady-state level, because the incentive to invest due to higher marginal product of private capital outweighs the disincentive from a higher tax rate on capital income.

From Figure 3, we see that various financing methods play a similar role here as for government consumption effects. Between domestic and external debt financing, private investment is crowded out more with domestic financing. Also, the public investment multipliers for output are bigger with the two external financing methods than with domestic financing (3). In fact the 10-year output multipliers are positive for external debt and aid financing (0.6 and 0.7, respectively), while the same multiplier is negative for domestic financing (−0.5).

A.   Public Investment Efficiency

Despite that public capital has an annual rate of return of 25.6 percent in the steady state, Table 3 shows that the output multipliers for public investment in the long run are much lower than 1. This seems puzzling, raising the question of how important is the assumed low level of public investment efficiency ($\epsilon = 0.4$) in explaining this result. Therefore, this section explores the importance of the marginal efficiency for public investment effects. The thought experiment assumes that the marginal efficiency of public investment is higher than the steady-state efficiency level of 0.4; in particular, ϵ in (40) is replaced by ϵ_t such that

$$\epsilon_t = \bar{\epsilon}\left(\frac{g_t^I - g^I}{g_t^I}\right) + \epsilon\left(\frac{g^I}{g_t^I}\right), \text{ if } g_t^I > g^I, \tag{49}$$

where $\bar{\epsilon} = 0.8$ is the marginal efficiency.

The specification in (49) captures, for example, joint ventures between Chinese companies and governments in Africa that are increasingly diversified—including investments in utilities, ports, roads, and bridges—and are likely to have a higher efficiency on new investment spending than traditional infrastructure projects implemented by local governments alone. In addition, it makes explicit that our experiment of changing efficiency raises the *marginal* efficiency, rather than the overall efficiency. Changing overall efficiency ϵ in (40) implies that the economy under a higher ϵ has more public capital in the steady state. But due to decreasing returns to capital, this translates into a lower marginal product of capital, compared to that with the lower ϵ. Thus, although a higher ϵ means that each dollar of investment spending generates more capital, each unit of capital is now less productive because the economy already has a lot of capital. With a Cobb-Douglas production function, these two effects perfectly offset each other, implying the same output multiplier for the higher and lower levels of overall efficiency (Berg et al., 2015). Only when marginal efficiency is different, the output multiplier of public investment can be affected.

Between the domestic and external debt financing, a higher marginal efficiency increases the output especially in later years. In particular, with external financing, the 10-year multiplier increases from 0.6 to 1.1 (see Table 4), and the long-run (20-year) cumulative output multiplier increases to 1.6. Coincidentally, this is comparable to the estimate in Ilzetzki et al. (2013) for a long-run output cumulative multiplier for the developing countries. However, this work does not have LICs in the sample and, like many other empirical studies, does not control for marginal efficiency aspects or for the type of financing.

The powerful role of marginal efficiency in raising the multiplier suggests that the key to enhance the growth effects of public investment in LICs is to improve efficiency, consistent with the viewpoint in International Monetary Fund (2014). This involves improving institution capacity and governance quality to reduce mistakes in selecting and supervising projects, corruption, and supply bottlenecks. The experiment here involves a one-time public investment shock. While the effects are long lasting, without continuous investment to

replenish depreciated capital, public capital eventually returns to its initial steady-state level. To sustain the growth benefits of public investment, a permanent increase in public investment is required such that the economy can move to a new steady state with more public capital and output.

B. Home Bias in Public Investment

Another important factor in determining the output multiplier of public investment, especially in the short run, is the degree of home bias in government purchases. The baseline assumes that both types of spending consist of 70 percent of nontraded goods ($\varphi^G = 0.7$). This assumption seems reasonable for overall spending in high income countries. In LICs, however, many public investment projects largely rely on imports of material, equipment, and skilled labor. As a result, the degree of home bias in investment spending can be much lower than 0.7.

We explore an alternative assumption setting the home bias in public investment at 0.3, while the one of government consumption remains at 0.7. Formally, let $\varphi^{GC} = 0.7$ and $\varphi^{GI} = 0.3$ be the degrees of home bias in g_t^C and g_t^I. The relative prices of these two types of government spending to the CPI then become

$$p_t^{GC} = \left[\varphi^{GC} \left(p_t^N \right)^{(1-\chi)} + \left(1 - \varphi^{GC} \right) (s_t)^{1-\chi} \right]^{\frac{1}{1-\chi}}, \tag{50}$$

and

$$p_t^{GI} = \left[\varphi^{GI} \left(p_t^N \right)^{(1-\chi)} + \left(1 - \varphi^{GI} \right) (s_t)^{1-\chi} \right]^{\frac{1}{1-\chi}}. \tag{51}$$

The term $p_t^G \left(g_t^C + g_t^I \right)$ in (39) and (47) is also replaced by $p_t^{GC} g_t^C + p_t^{GI} g_t^I$. Figure 4 compares the short-run effects under $\varphi^{GI} = 0.7$ (baseline, solid lines) and the current specification $\varphi^{GI} = 0.3$ (dotted-dashed lines) with domestic and external debt financing.[38]

When the degree of home bias is small, traded output outperforms nontraded output, which is the opposite to the pattern under a higher degree of home bias. With domestic debt financing, higher government demand for traded goods leads to a real *depreciation*, generating positive responses of traded output, reversing the real appreciation in earlier analysis.[39] Consistent with our results in the simple model, government purchases that consist of more traded goods can generate a real depreciation and stimulate traded output (see also Penati (1987)). A lower degree of home bias in public investment implies that a higher share of the demand from government spending increases is met by imports. Thus, public spending is less effective in

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[38]Short-run dynamics with aid financing are similar to the dynamics under external debt financing.

[39]Empirically, whether a government spending increase results in a real depreciation or appreciation is inconclusive. Many empirical studies using data of developed countries find real depreciation (e.g., Kim and Roubini (2008) and Monacelli and Perotti (2010)). Ilzetzki et al. (2013) find a brief but significant real appreciation for the developing country sample.

promoting domestic production and is associated with a smaller output multiplier. With external debt financing, for instance, the impact output multiplier under $\varphi^{GI} = 0.3$ is 0.15, compared to 0.40 under $\varphi^{GI} = 0.7$.

VII. Conclusion

Government spending is an important policy instrument in LICs, both to counteract business cycles and to promote growth. Despite its importance, few efforts have been devoted to study fiscal policy effects in these countries. This paper contributes to the literature by using a DSGE and NK approach to study government consumption and public investment effects in LICs. The quantitative model takes into account prominent LIC-specific features, including a large share of hand-to-mouth households and limited international capital mobility in the private sector, but the analysis focuses on three key features: the type of financing for government spending, the marginal efficiency of public investment and the home bias of government purchases.

The analysis highlights several important results. With limited international capital mobility, the output multiplier is generally bigger with external (debt or aid) than with domestic financing. External financing increases the resources available for the economy, mitigating the crowding-out effects of government spending. A large inflow of foreign exchange with external financing, however, appreciates the real exchange rate and reduces traded output. Moreover, the general impression that capital scarcity in LICs renders public investment a large positive growth effect, and therefore large long-run output multipliers, needs some qualification. While the return to public capital can be high, the output multiplier can still be much lower than one if the *marginal* efficiency of public investment is low. Furthermore, public investment is unlikely to deliver strong short-run stimulative output effects because of a relatively low degree of home bias in investment spending.

The quantitative model is currently calibrated to an average LIC. If sufficient quarterly data were available, the model could be estimated to evaluate the empirical importance of the LIC features introduced here. In addition, efforts in estimating country-specific parameters—such as the marginal efficiency or the public spending home bias—and attempts to disentangle the different types of government spending according to their financing source would be useful not only for applying the model to evaluate country-specific spending effects, but also for the empirical literature of output multipliers in developing countries, which so far has ignored some of the features discussed in this paper.

Finally, the paper focuses on features relevant for LICs, but it leaves out state-dependent government spending effects, shown to be important for advanced or emerging market economies. State-dependent fiscal policy effects have gained substantial interest since the global financial crisis in 2007-08. The binding zero-lower bound on the nominal interest rate, the deep recession, and rising government debt levels have inspired research in government spending effects against different states, including monetary policy (e.g., Christiano et al.

(2011) and Erceg and Lindé (2014)), business cycles (e.g., Corsetti et al. (2010), Auerbach and Gorodnichenko (2012), Blanchard and Leigh (2013), and Owyang et al. (2013)), and government indebtedness (e.g., Ilzetzki et al. (2013) and Bi et al. (2015)). These states are likely to be relevant for LICs and are topics of interest for future research.

APPENDIX I.   SOLVING THE ANALYTICAL MODEL

This appendix presents the reduced equilibrium conditions, the steady state, and the linearized equilibrium system for the model in Section II.

A.   Optimality, Steady State, and Log-linearization

- Equilibrium Conditions:

$$\mathfrak{a}_T \left(l_t^T \right)^\psi = c_t^{-\sigma} w_t^T, \tag{I.1}$$

$$\mathfrak{a}_N \left(l_t^N \right)^\psi = c_t^{-\sigma} w_t^N, \tag{I.2}$$

$$c_t^{-\sigma} = \beta \mathbb{E}_t \left(\frac{c_{t+1}^{-\sigma} R_t}{\pi_{t+1}} \right), \tag{I.3}$$

$$c_t^T = (1 - \varphi) \, s_t^{-\chi} c_t \quad \text{and} \quad c_t^N = \varphi \left(p_t^N \right)^{-\chi} c_t, \tag{I.4}$$

$$1 = \varphi \left(p_t^N \right)^{1-\chi} + (1 - \varphi) \, s_t^{1-\chi}, \tag{I.5}$$

$$m_t^{-\xi} = c_t^{-\sigma} \left(1 - \frac{1}{R_t} \right), \tag{I.6}$$

$$s_t = w_t^T, \quad mc_t = \frac{w_t^N}{p_t^N}, \tag{I.7}$$

$$\pi_t^N \left(\pi_t^N - 1 \right) = \beta \mathbb{E}_t \left[\frac{c_{t+1}^{-\sigma} p_{t+1}^N y_{t+1}^N}{c_t^{-\sigma} p_t^N y_t^N} \left(\pi_{t+1}^N - 1 \right) \pi_{t+1}^N \right] + \frac{\theta}{\zeta (1 + u)} \left[mc_t - \frac{(\theta - 1)(1 + u)}{\theta} \right], \tag{I.8}$$

where $\pi_t^N \equiv \frac{p_t^N}{p_{t-1}^N} \pi_t$ is the inflation to the nontraded goods,

$$g_t^N = \varphi^G \left(\frac{p_t^N}{p_t^G} \right)^{-\chi} g_t \quad \text{and} \quad g_t^T = (1 - \varphi^G) \left(\frac{s_t}{p_t^G} \right)^{-\chi} g_t, \tag{I.9}$$

$$p_t^G = \left[\varphi^G \left(p_t^N \right)^{1-\chi} + (1 - \varphi^G) \, s_t^{1-\chi} \right]^{\frac{1}{1-\chi}}, \tag{I.10}$$

$$R_t = R \mathbb{E}_t \left(\frac{\pi_{t+1}^N}{\pi^N} \right)^{\phi_\pi}, \tag{I.11}$$

$$\omega \Delta g_t = s \Delta a_t^*, \tag{I.12}$$

$$\Delta g_t = \rho \Delta g_{t-1} + \varepsilon_t, \tag{I.13}$$

$$y_t^N = l_t^N = c_t^N + g_t^N + \frac{\zeta}{2} \left(\pi_t^N - 1 \right)^2 y_t^N p_t^N, \tag{I.14}$$

$$y_t^T = l_t^T = c_t^T + g_t^T - a_t^*, \tag{I.15}$$

$$y_t = p^N y_t^N + s y_t^T. \tag{I.16}$$

Note that by assumption, z_t always adjusts to satisfy (39), so we can exclude the government budget constraint from the analysis.

- Steady State (for simplicity ignore money):

Recall that we assumed that the subsidy u removes the monopolistic power in the steady state. Then at the steady state (I.8) implies that $mc = 1$, as long as $\pi_N = 1$. Moreover, since the labor disutility parameters satisfy $\mathfrak{a}_N = \varphi^{-\psi}$ and $\mathfrak{a}_T = (1 - \varphi)^{-\psi}$ then use (I.1) and (I.2) to obtain:

$$\frac{w^T}{w^N} = \frac{(1 - \varphi)^{-\psi}}{\varphi^{-\psi}} \left(\frac{l^T}{l^N} \right)^\psi . \tag{I.17}$$

Combining $mc = 1$ and (I.7) at the steady state yields

$$\frac{s}{p^N} = \frac{w^T}{w^N}, \tag{I.18}$$

while the simplifying assumption $g = a^* = 0$ together with equation (I.4), (I.9), (I.14) and (I.15) imply that

$$\frac{l_t^T}{l_t^N} = \frac{(1 - \varphi)}{\varphi} \left(\frac{s}{p^N} \right)^{-\chi} . \tag{I.19}$$

Then use (I.17)-(I.19) to deduce that

$$\frac{s}{p^N} = 1,$$

which together with (I.5), (I.7), and (I.10) mean that

$$s = p^N = p^G = w^N = w^T = 1. \tag{I.20}$$

Furthermore, apply (I.20) and $g = a^* = 0$ to (I.4), (I.9), (I.14), and (I.15) to obtain

$$y^N = l^N = c^N = \varphi c \quad \text{and} \quad y^T = l^T = c^T = (1 - \varphi)c. \tag{I.21}$$

The first equation of (I.21), $\mathfrak{a}_N = \varphi^{-\psi}$ and (I.2) can be combined to derive that $c = 1$, which can be replaced into (I.21) to deduce that $y^N = l^N = c^N = \varphi$ and $y^T = l^T = c^T = 1 - \varphi$. These and (I.16) imply that $y = 1$.

Since the target inflation at the steady state satisfies $\pi^N = 1$, and $\pi^N = \pi$, then $\pi = 1$. This with (I.3) implies that $R = 1/\beta$.

- Log-linearized Equilibrium (for simplicity ignore money):

For simplicity we assume that $\sigma = \chi = 1$. Recall that at the steady state $g = a^* = 0$, so the variables g_t, g_t^N, g_t^T, and a_t^* cannot be log-linearized but have to be expressed as deviations from the steady state. Therefore, the approximated equilibrium conditions of the model correspond to

$$\psi \hat{l}_t^T = \hat{w}_t^T - \hat{c}_t, \tag{I.22}$$

$$\psi \hat{l}_t^N = \hat{w}_t^N - \hat{c}_t, \tag{I.23}$$

$$\mathbb{E}_t \hat{c}_{t+1} - \hat{c}_t = \left(\hat{R}_t - \mathbb{E}_t \hat{\pi}_{t+1} \right), \tag{I.24}$$

$$\hat{c}_t^N = \hat{c}_t - \hat{p}_t^N, \qquad \hat{c}_t^T = \hat{c}_t - \hat{s}_t, \tag{I.25}$$

$$\hat{mc}_t = \hat{w}_t^N - \hat{p}_t^N, \tag{I.26}$$

$$\hat{w}_t^T = \hat{s}_t, \tag{I.27}$$

$$\hat{\pi}_t^N = \beta \mathbb{E}_t \hat{\pi}_{t+1}^N + \frac{\theta - 1}{\zeta} \hat{mc}_t, \tag{I.28}$$

$$\hat{R}_t = \phi_\pi \mathbb{E}_t \hat{\pi}_{t+1}^N, \tag{I.29}$$

$$\varphi \hat{y}_t^N = \varphi \hat{l}_t^N = \varphi \hat{c}_t^N + \Delta g_t^N, \tag{I.30}$$

$$(1 - \varphi)\hat{y}_t^T = (1 - \varphi)\hat{l}_t^T = (1 - \varphi)\hat{c}_t^T + \Delta g_t^T - \Delta a_t^*, \tag{I.31}$$

$$\Delta g_t^N = \varphi^G \Delta g_t \quad \text{and} \quad \Delta g_t^T = (1 - \varphi^G)\Delta g_t, \tag{I.32}$$

$$\Delta a_t^* = \omega \Delta g_t, \tag{I.33}$$

$$\hat{p}_t^N = -\frac{(1-\varphi)}{\varphi}\hat{s}_t, \tag{I.34}$$

$$\hat{p}_t^G = \left(1 - \frac{\varphi^G}{\varphi}\right)\hat{s}_t, \tag{I.35}$$

$$\hat{\pi}_t^N = \hat{p}_t^N - \hat{p}_{t-1}^N + \hat{\pi}_t, \tag{I.36}$$

$$\hat{y}_t = \varphi\hat{y}_t^N + (1-\varphi)\hat{y}_t^T. \tag{I.37}$$

Combine (I.22), (I.25), (I.27), (I.31), (I.32), and (I.33) to obtain

$$\hat{s}_t = \hat{c}_t + \left(\frac{1-\omega-\varphi^G}{1-\varphi}\right)\left(\frac{\psi}{1+\psi}\right)\Delta g_t, \tag{I.38}$$

which together with (I.13) implies that

$$\mathbb{E}_t(\hat{s}_{t+1} - \hat{s}_t) = \mathbb{E}_t(\hat{c}_{t+1} - \hat{c}_t) + \left(\frac{1-\omega-\varphi^G}{1-\varphi}\right)\left(\frac{\psi}{1+\psi}\right)(\rho-1)\Delta g_t. \tag{I.39}$$

Use (I.23), (I.25), (I.26), (I.30), (I.32), (I.33) and (I.34) to obtain

$$\hat{mc}_t = \left(\frac{1+\psi}{\varphi}\right)\hat{c}_t + \left(\frac{\psi}{\varphi}\right)(1-\omega)\Delta g_t. \tag{I.40}$$

Next, combine (I.34) and (I.36) to get

$$\hat{\pi}_t = \hat{\pi}_t^N + \frac{1-\varphi}{\varphi}\left(\hat{s}_t - \hat{s}_{t-1}\right), \tag{I.41}$$

which together with (I.39) imply that

$$\mathbb{E}_t\hat{\pi}_{t+1} = \left(\frac{1-\varphi}{\varphi}\right)\mathbb{E}_t(\hat{c}_{t+1}-\hat{c}_t) + \left(\frac{1-\omega-\varphi^G}{\varphi}\right)\left[\frac{\psi(\rho-1)}{1+\psi}\right]\Delta g_t + \mathbb{E}_t\hat{\pi}_{t+1}^N. \tag{I.42}$$

Subtract (I.42) from (I.29) to obtain

$$\hat{R}_t - \mathbb{E}_t\hat{\pi}_{t+1} = (\phi_\pi - 1)\mathbb{E}_t\hat{\pi}_{t+1}^N - \left(\frac{1-\varphi}{\varphi}\right)\mathbb{E}_t(\hat{c}_{t+1}-\hat{c}_t) - \left(\frac{1-\omega-\varphi^G}{\varphi}\right)\left[\frac{\psi(\rho-1)}{1+\psi}\right]\Delta g_t. \tag{I.43}$$

Use (I.43) in (I.24) to obtain (23)

$$\hat{c}_t = \mathbb{E}_t \hat{c}_{t+1} - \underbrace{\varphi\left(\phi_\pi - 1\right)}_{\Theta_\pi} \mathbb{E}_t \hat{\pi}_{t+1}^N - \underbrace{\frac{\left(1 - \omega - \varphi^G\right)\left(1 - \rho\right)\psi}{1 + \psi}}_{\Theta_g} \Delta g_t. \qquad \text{(I.44)}$$

Last, combine (I.28) and (I.40) to derive (24)

$$\hat{\pi}_t^N = \beta \mathbb{E}_t \hat{\pi}_{t+1}^N + \underbrace{\frac{(\theta - 1)(1 + \psi)}{\zeta\varphi}}_{\Gamma_c} \hat{c}_t + \underbrace{\frac{(\theta - 1)\left(1 - \omega\right)\psi}{\zeta\varphi}}_{\Gamma_g} \Delta g_t. \qquad \text{(I.45)}$$

B. Proofs of Propositions

1. Proof of Proposition 1

Proof. The proof has two parts. First, we prove the existence of a unique equilibrium (stability). Second, we apply the method of undetermined coefficients to derive the analytical solution and characterize the equilibrium for $\hat{c}_t$.

To prove equilibrium uniqueness, part *a*), we rewrite equations (23), and (24) as the system

$$\hat{x}_t = \mathbf{D}\mathbb{E}_t \hat{x}_{t+1} + \mathbf{N}\Delta g_t, \qquad \text{(I.46)}$$

where $\hat{x}_t = \begin{bmatrix} \hat{c}_t & \hat{\pi}_t^N \end{bmatrix}'$,

$$\mathbf{D} = \begin{bmatrix} 1 & -\Theta_\pi \\ \Gamma_c & \beta - \Gamma_c\Theta_\pi \end{bmatrix}, \qquad \mathbf{N} = \begin{bmatrix} -\Theta_g \\ \Gamma_g - \Gamma_c\Theta_g \end{bmatrix},$$

$\Theta_\pi = \varphi\left(\phi_\pi - 1\right)$, $\Theta_g = \frac{\left(1 - \varphi^G - \omega\right)(1 - \rho)\psi}{(1 + \psi)}$, $\Gamma_c = \frac{(\theta - 1)(1 + \psi)}{\zeta\varphi}$, and $\Gamma_g = \frac{(\theta - 1)(1 - \omega)\psi}{\zeta\varphi}$. The characteristic polynomial associated with $\mathbf{D}$ is given by

$$\mathcal{P}(\lambda) = \lambda^2 - \left(\beta + 1 - \Gamma_c\Theta_\pi\right)\lambda + \beta,$$

with $|\mathbf{D}| = \beta \in (0, 1)$. Define $\Sigma \equiv \left(\frac{\theta - 1}{\zeta}\right)\left(1 + \psi\right)$. Since $\theta > 1$, $\varphi \in (0, 1)$, and $\psi, \zeta > 0$, we have $\Sigma > 0$. Moreover, setting $\lambda = 1$, we obtain

$$\mathcal{P}(1) = \Gamma_c\Theta_\pi = \Sigma\left(\phi_\pi - 1\right) > 0, \text{ iff } \phi_\pi > 1.$$

And setting $\lambda = -1$, we obtain

$$\mathcal{P}(-1) = \Sigma \left[\frac{2(1+\beta) + \Sigma}{\Sigma} - \phi_\pi \right] < 0, \text{ iff } \phi_\pi < 1 + \frac{2(1+\beta)}{\Sigma}.$$

Since $|\mathbf{D}| \in (0, 1)$, $\mathcal{P}(1) > 0$, and $\mathcal{P}(-1) > 0$, following Azariadis (1993), we can infer that both eigenvalues of $\mathbf{D}$— λ_1 and λ_2—are inside the unit circle. Given this and the fact that there are two non-predetermined variables—$\hat{c}_t$ and $\hat{\pi}_t^N$—then the results of Blanchard and Kahn (1980) imply that there exists a unique rational expectations equilibrium.

To prove part *b*), we follow the undetermined coefficient method (see Christiano (2002)) and postulate the following Minimal State Variable (MSV) representation of the rational expectations solution:

$$\hat{c}_t = \nu \Delta g_t \quad \text{and} \quad \hat{\pi}_t^N = \mu \Delta g_t,$$

which can be written in a compact form as:

$$\hat{x}_t = \mathbf{V} \Delta \hat{g}_t, \tag{I.47}$$

with $\hat{x}_t = [\ \hat{c}_t \quad \hat{\pi}_t^N\ ]'$ and $\mathbf{V} = [\ v \quad \mu\ ]'$. Iterating forward the MSV (I.47) and using it together with the stochastic process (22) to eliminate all the forecasts $\mathbb{E}_t \hat{x}_{t+1}$ as well as $\hat{x}_t$ in the model (I.46), we obtain $(\mathbf{V} - \rho \mathbf{D} \mathbf{V} - \mathbf{N}) \Delta g_t = \mathbf{0}$ which implies the following mapping:

$$\mathbf{V} - \rho \mathbf{D} \mathbf{V} - \mathbf{N} = \mathbf{0}.$$

This mapping defines a set of equations for the elements v and μ of the matrix $\mathbf{V}$ that can be solved in terms of the elements of the matrices $\mathbf{D}$ and $\mathbf{N}$. Solving these equations yields

$$\nu = -\frac{\psi}{1 + \psi} \left[1 - \omega - \left(\frac{\eth}{\eth + \mathfrak{n}} \right) \varphi^G \right],$$

where $\eth$ and $\mathfrak{n}$ are defined in (25).   *Q.E.D.*

2.   Proof of Proposition 2

Proof. The expression (27) for the multiplier $\mathbf{M}_c$ follows from using the rational expectations solution (25) from Proposition 1 and the fact that $c = 1$. The crowding-out and crowding-in results, $\mathbf{M}_c \lesseqgtr 0$, can be verified by applying the conditions $(1 - \omega) \gtreqless \frac{\partial \varphi^G}{\partial + \mathfrak{n}}$ to

(27). Note that $0 \leq \omega \leq 1$, $0 \leq \varphi^G \leq 1$, $0 < \eth < 1$, and $\mathfrak{n} > 0$, given the assumptions about the structural parameters. Finally the implications of external financing on the multiplier, part *b)*, are determined by taking the derivative of (27) with respect to the parameter ω to obtain $\frac{\partial \mathbf{M}_c}{\partial \omega} = \frac{\psi}{1+\psi} > 0$, given that $\psi > 0$. Similarly, part *c)* follows from taking the derivative of (27) with respect to the parameter φ^G. Hence $\frac{\partial \mathbf{M}_c}{\partial \varphi^G} = \left(\frac{\psi}{1+\psi}\right)\left(\frac{\eth}{\eth+\mathfrak{n}}\right) > 0$, given that $\psi > 0$, $0 < \eth < 1$, and $\mathfrak{n} > 0$. *Q.E.D.*

3. Proof of Proposition 3

Proof. To derive the expressions in (28) for the multipliers we use and manipulate expressions (25), (I.22), (I.23), (I.25)-(I.27), and (I.30)-(I.34). Part *a)*, $\mathbf{M}_{y^T} \lesseqgtr 0$, is easily verified by applying the condition $1 \lesseqgtr \omega + \varphi^G$ on $\mathbf{M}_{y^T}$ in (28), while recalling that $\psi > 0$. For part *b)*, we take the derivatives of $\mathbf{M}_{y^T}$: $\frac{\partial \mathbf{M}_{y^T}}{\partial \omega} = \frac{\partial \mathbf{M}_{y^T}}{\partial \varphi^G} = -\frac{1}{1+\psi} < 0$. Finally for part *c)*, it is simple to note that $\mathbf{M}_{y^N} \geq 0$, as long as $0 \leq \varphi^G \leq 1$, $0 < \eth < 1$, $\mathfrak{n} > 0$, and $\psi > 0$, and that $\frac{\partial \mathbf{M}_{y^T}}{\partial \varphi^G} = \left[\frac{\eth+\mathfrak{n}/(1+\psi)}{\eth+\mathfrak{n}}\right] > 0$. *Q.E.D.*

parameters	values	
v	10	implying limited international capital mobility
β	0.98	the discount factor
σ	2.94	inverse of intertemporal elasticity of substitution for consumption, savers
ψ	1	inverse of Frisch labor elasticity, savers
ξ	11.4	inverse of intertemporal elasticity of substitution for m_t, savers
φ	0.6	degree of home bias in private consumption and investment
φ^G	0.7	degree of home bias in government consumption and investment
χ	0.44	elasticity of substitution between traded and nontraded goods
θ	6	elasticity of substitution among nontraded goods
u	0.2	subsidy rate to remove monopolistic power in steady state
f	0.25	fraction of savers
κ	1.4	investment adjustment cost parameter
δ	0.025	depreciation rate of private capital
φ^l	0.58	steady-state labor share in nontraded good sector
χ^l	0.6	elasticity of substitution between labor of two sectors
z^N	1	TFP in non-traded good sector, normalization
α^N	0.45	labor income share in nontraded output
α^T	0.60	labor income share in traded output
α^G	0.11	output elasticity with respect to public capital
δ^G	0.012	depreciation rate of public capital
ζ	76.7	price adjustment cost parameter
ι	0.38	implicit production cost parameter
ϵ	0.4	steady-state public investment efficiency
R	1.04	domestic nominal interest rate
R^*	1.03	foreign nominal interest rate
π	1.02	quarterly CPI inflation
π^*	1.02	foreign inflation
μ	1.02	nominal money growth rate
τ	0.17	income tax rate
ρ_τ	0.9	AR(1) coefficient in tax rule
γ	0.01	tax response parameter to changes in debt-to-output ratio
ρ_G	0.9	AR(1) coefficient in government spending rules
$\frac{c}{y}$	0.71	private consumption to output ratio
$\frac{i}{y}$	0.14	private investment to output ratio
$\frac{tb}{y}$	-0.13	trade balance to output ratio
$\frac{g_C}{y}$	0.155	government consumption to output ratio
$\frac{g_I}{y}$	0.045	public investment to output ratio
$\frac{b}{s^b}$	0.33	total public debt to annual output ratio
$\frac{b^{g*}}{4y}$	0.20	external public debt to annual output ratio
$\frac{b^{h*}}{4y}$	0.094	external private debt to annual output ratio
$\frac{sa^*}{y}$	0.047	aid to output ratio

Table 1. **Baseline Calibration and Some Steady-State Values**

domestic debt financing					
	y_t	y_t^N	y_t^T	c_t	i_t	tb_t
impact	0.4	0.3	0.1	0.1	−0.7	−0.0
5 years	−0.4	−0.0	−0.3	−0.6	−0.8	0.0
external debt financing					
impact	0.4	0.8	−0.3	0.5	−0.5	−0.5
5 years	0.2	1.0	−0.8	−0.0	0.0	−0.5
aid financing					
impact	0.4	0.8	−0.3	0.5	−0.7	−0.5
5 years	0.1	1.1	−0.9	0.0	0.0	−0.9

Table 2. **Cumulative multipliers for government consumption: baseline calibration.**

domestic debt financing					
	y_t	y_t^N	y_t^T	c_t	i_t	tb_t
impact	0.3	0.2	0.1	0.2	−0.8	−0.0
10 years	−0.5	−0.1	−0.4	−0.6	−0.9	0.0
external debt financing					
impact	0.4	0.8	−0.4	0.5	−0.6	−0.6
10 years	0.6	1.0	−0.4	0.1	−0.0	−0.8
aid financing					
impact	0.4	0.8	−0.4	0.6	−0.6	−0.6
10 years	0.7	1.4	−0.7	0.5	0.1	−0.9

Table 3. **Cumulative multipliers for public investment: baseline calibration.**

domestic debt financing					
	y_t	y_t^N	y_t^T	c_t	i_t	tb_t
impact	0.3	0.2	0.1	0.2	−0.9	−0.0
10 years	−0.0	0.2	−0.2	−0.2	−0.8	0.0
external debt financing					
impact	0.4	0.8	−0.4	0.6	−0.7	−0.6
10 years	1.1	1.3	−0.2	0.6	0.0	−0.8
aid financing					
impact	0.4	0.8	−0.5	0.6	−0.7	−0.6
10 years	1.2	1.6	−0.4	0.9	0.2	−0.9

Table 4. **Cumulative multipliers for public investment: higher efficiency with $\epsilon = 0.8$ for the investment increase.**
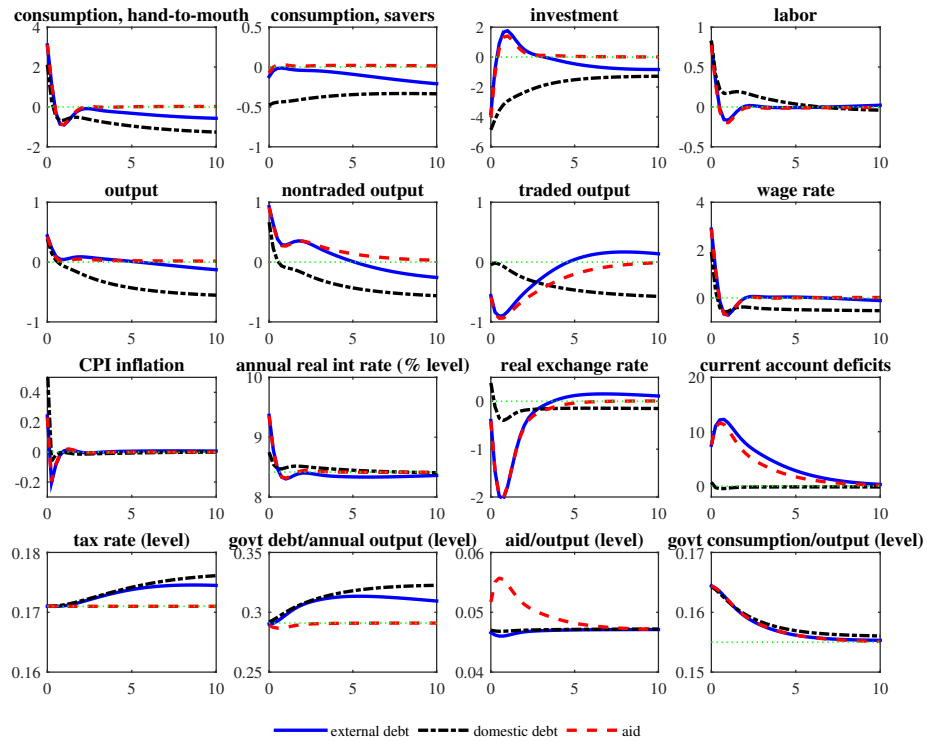
Figure 1. **Impulse responses to a government consumption increase: baseline calibration.** The x-axis is in years. The y-axis is in percent deviation from the steady state unless noted in parentheses.
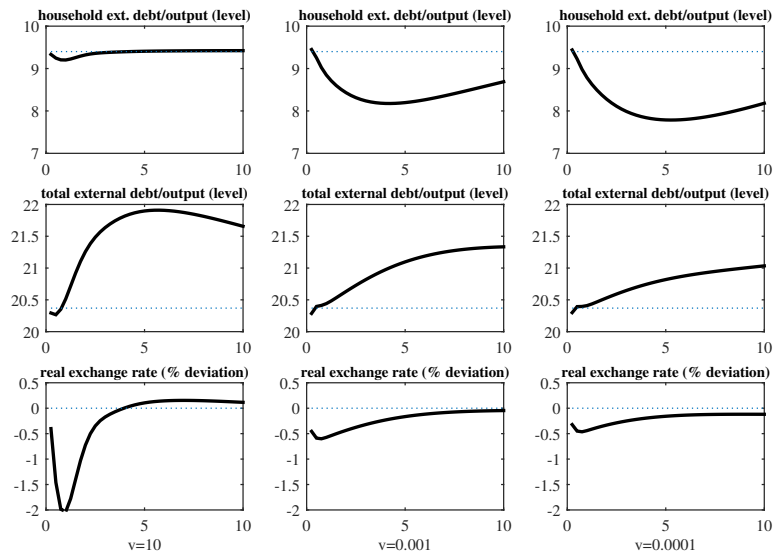

Figure 2. **Government consumption effects under different capital mobility.** The x-axis is in years. The size of the government consumption shock is the same as in Figure 1.
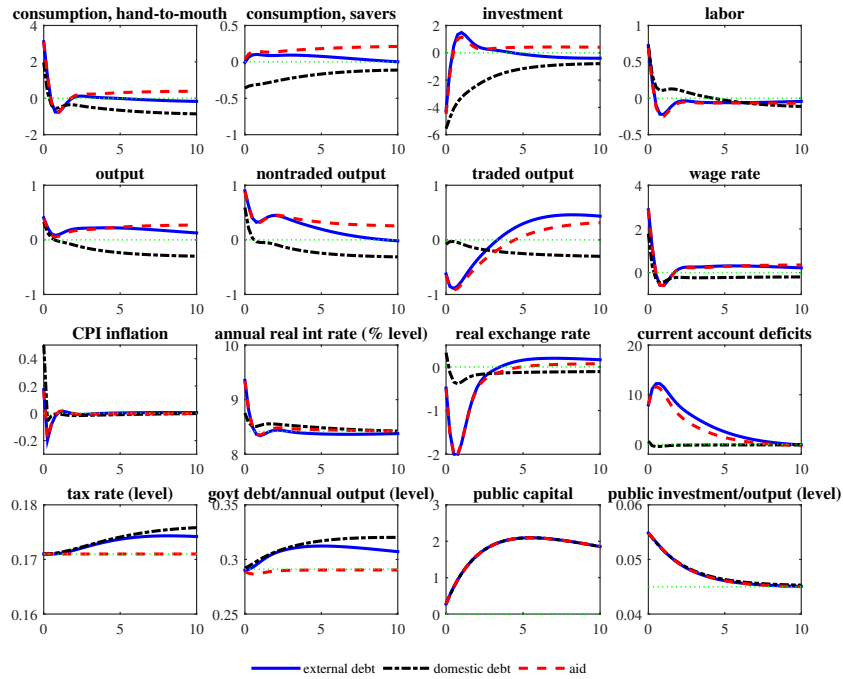
Figure 3. **Impulse responses to a public investment increase: baseline calibration.** The units are same as in Figure 1.
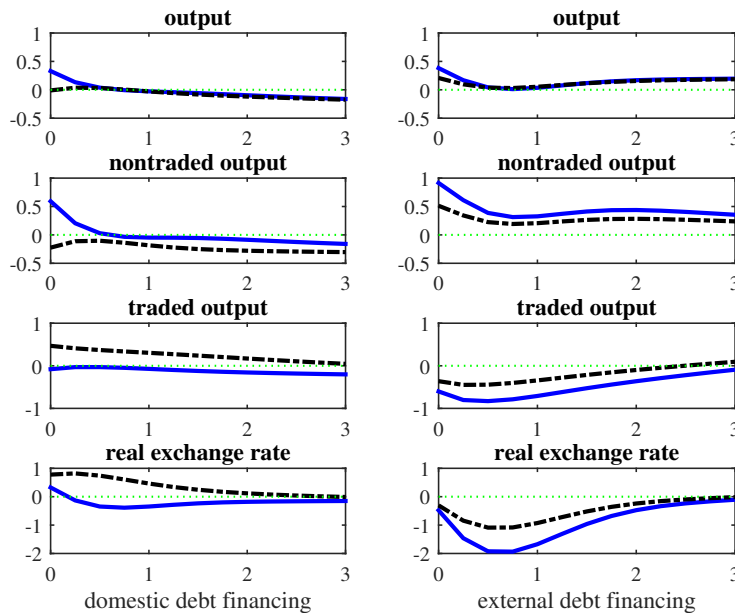

Figure 4. **Public investment effects with different degree of home bias.** Solid lines assume $\varphi^{GC} = \varphi^{GI} = 0.7$ (baseline); dotted-dashed lines assume $\varphi^{GC} = 0.7$ and $\varphi^{GI} = 0.3$. The x-axis is in years. The y-axis is in percent deviation from the steady state.

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